MODULAR, POST-PROGRAMMABLE, RADIO FREQUENCY LOCATION, IDENTIFICATION, TRACKING, MONITORING, INTERROGATION AND SENSING SYSTEM, COMPONENTS AND METHODS

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Abstract

A set of system hardware components designed to provide the ability to select subsets that can be combined into a variety of customized systems for use in a wide range of Radio Frequency Location, Identification, Tracking, Monitoring, Interrogation and Sensing Functions. The set of hardware components consists of three categories of plug-in systems components: Transponders, Readers and Pollers. The Transponders have modularized components including a power module, a micro-controller module, a family of sensor/communication/interface modules, and configuration and attachment hardware. The Readers consist of PCBs that can be integrated into PDAs or PC-104 computers, PCMCIA Reader cards that can be used with any computer having a PCMCIA slot, and complete Readers that have communication links such as LAN, WLAN, Cell Phone, Internet and radio. The Pollers consist of a selection of components that provide simple keying transmissions to awake or change the mode of the Transponders, or transmit operating instructions to the transponder or provide information that can be relayed by the Transponder to the Reader. All of the processor based system components are customer programmable and can be interchanged between applications in the field. A single Reader can be programmed to receive and decode any combination of Transponder configurations that may be within its reception range at any time. The Reader can have as many as eight PIN diode-switched and arrayed antennae that can share a single receiver channel and combined with a 16-bit signal strength measurement means, can locate transponders within a foot or two over large areas, even deep underground.

BACKGROUND OF INVENTION

The present invention relates to apparatus and methods for remotely locating, identifying, tracking, monitoring, interrogating and sensing such items as containers and container contents, vehicles, crates, packages and personal belongings; people in theme parks, cruise liners, multistory buildings, university campuses, golf courses and shopping malls; and the conditions of vehicle wheel and axle systems, clean room environments, water quality, aircraft systems and the contents of vending machines. Other remote access applications include video surveillance, radioactivity monitoring, sniffing for explosives and drugs, and other security and law enforcement activities. More generally the invention relates to apparatus and methods that utilize sensors, processors and programmed transmitters that store unique encoded data, can receive data and instructions from remote sources, and can transmit this information to readers that receive, decode and present the information for review, analysis and the determination of appropriate action. Furthermore with the ability to send emergency information immediately on the SMS Data Channel of Cell Phone communications or summary data

over the Internet, any sensed or monitoring information can be delivered in real time to anywhere in the world, all with a single reader or with an arrayed set of identical readers.

Many systems exist that provide some specific function or functions described above but none have achieved the degree of standardization or universal applicability that enables a system to be customized to meet certain application requirements without the need to develop new and untried hardware variations or that can be integrated into a common information collection system. This can only be achieved by a concept that addresses the nature of mechanical versatility, functionally modularity, real time programmability and environmental adaptability. A hardware system and method that is essentially application independent but can be constrained to specific applications, to the extent necessary, by solution providers who incorporate appropriate custom firmware and software.

The most critical aspect of the invention is the modularized nature of the Transponder and its mechanical and functional versatility. It consists of three primary elements, two of which are common to all applications and environments described previously. They are the power module and the main module that contains a micro-controller and the RF communication circuitry. These two modules are sealed and plug together to first form a mechanical link and when further compressed, to achieve an electrical link. An intervening adapter is used for certain applications. The third element plugs into the opposite side of the main module and can have a variety of features from simply a sealed cap to protect the connector when used only for testing, programming and only beacon application, to a custom connector module for interfacing with customer provided sensors, and a wide choice of active sensing and communicating modules, that can range from GPS and Fixed Frame Video, to Wheel and Axle Monitoring that includes pressure, temperature, acceleration and acoustic sensors, and to the inclusion of a variety of telemetry functions. This third module may also require the intervening adapter when used for certain applications. All three modules have cleats that provide standoff and attachment means appropriate to stand high shock and g-force stresses.

Another key feature of the system is the means by which transponders configured for the complete range of possible applications from any sensing function to real time inventory tracking, from vehicle wheel and axle monitoring, from GPS position location identification to fixed frame video surveillance, can all be read together using the same Receiver. This is possible because the transponder for all these applications is the same except for the special purpose module, and the data encoding is the same for all transponders except for the word length and the nature of the encoded information. Part of the transmitted code contains information needed by the decoder in order to recognize the data as coming from a unique transponder, in other words the beginning and ending of the word. The nature of the encoded information is programmed into the Reader software as a look-up table and identified through the transponder's individual code.

For example; the encoding scheme allows up to 16 revisions of the transponder all able to be individually identified when reading their transmissions, and each revision can identified to provide over 5000 customers with the same revision and be able to distinguish each customer's product; it can also provide for up to 128 different kinds of

sensor module attached to the transponder and be able to relate each transmission to the type of module; it can provide up to 100,000 unique tags for each sensor type before repeating a code. Furthermore it is able to transmit 128 different temperatures, 128 different pressures, 16 different battery voltages and GPS location, or other sensed parameters for each sensor module version. With start bits and check sum/parity bits, the reader can receive and decode information from any and all of these transponders and present all the monitored information categorized by transponder revision, customer, sensor configuration and individual transponder. This provides for a truly backwards and forwards compatible system.

The Signal Strength Indication technology imbedded in the Reader consists of a 16-bit comparator. The accurate location features of the system integrate this SSI feature with the PIN diode-switched eight antenna array. This eight-antenna array can be configured as four pairs of dual orthogonal antennae located equidistant from the Reader in a North, East, South and West type of deployment or if diversity is not required the Reader can handle a distributed array of eight antennae, providing an even more accurate location capability. In applications where the high gain antennae are used to provide significant range (such as omni angle or Yagi) a Low Noise Amplifier may be required at each antenna.

Examples of this deployment are:

Using ¼ wave helical antennae the transponder read range is typically 100' to 125'. In this case the antennae are located 50 feet from the Reader in perpendicular directions. The SSI sensitivity is ±1.5 feet near the Reader to ±4 feet far from the Reader, over an area of approximately 32,000 sq ft, using a single reader. By using additional, appropriately located Readers, the accuracy can be maintained at ±1.5 feet over a much larger area. About 1000 readers would be required to cover a square mile instead of about 5000 conventional Readers with the same antenna.

Using ¼ wave whip antennae the transponder read range is typically 150' to 175'. In this case the antennae are located 75 feet from the Reader in perpendicular directions. The SSI sensitivity is ±2.5 feet near the Reader to ±6 feet far from the Reader, over an area of approximately 65,000 sq ft, using a single reader. By using additional, appropriately located Readers, the accuracy can be maintained at ±2.5 feet over a much larger area. About 500 readers would be required to cover a square mile instead of about 2500 conventional Readers with the same antenna.

Using high-gain omni-antennae the transponder read range is typically 400' to 450'. In this case the antennae are located 200 feet from the Reader in perpendicular directions.

The Reader has a number of wireless connectivity options that are achieved by using a multi-protocol processor and software platforms that address the 802.11, Bluetooth, HomePlug, Ethernet, SMS, GSM, CDSA and USB networking protocols, providing solutions that are designed for deployment in wireless access points, gateways and VOIP phones, and in commercial/industrial equipment. This provides the ability to standardize

LITMIS systems around a single platform while preserving the flexibility to bring a wide variety of product variations into an integrated system via software changes only. This enables compliance with the latest specifications that can be executed instantaneously through software upgrade through the Internet. The integration of this technology in the Reader provides a single adaptable platform, enabling connectivity with numerous communications and device physical interfaces like 802.11, Ethernet, MII, I2C, SPI, GPSI, UART and USB. The heart of this feature is a 120MIPS deterministic processor, complemented with on-chip high-speed flash and SRAM memory. Two full-duplex serializers/deserializers enable software implementation of most common device I/O including on-chip Ethernet MAC and PHY.

DESCRIPTION OF DRAWINGS

Drawing 01 shows a vehicle wheel with WAMS transponder attached. The main module 2, tapered power module separator 3 and battery module 4 are visible. The transponder is attached with strap 5 and grommet 6 and is positioned in the drop center of the wheel 7.

Drawing 01 is another view of the wheel showing the complete WAMS transponder showing the sensor module 8 and tapered sensor separator 9.

Drawing 03 is a view of the transponder sections, mounting cleats 10, strap 5 and grommet 6. As in previous drawings the transponder consists of main module 2, tapered power module separator 3, power module 4, sensor module 8 and tapered sensor separator 9.

Drawing 04 is an underside view of the modular transponder showing the cleats 10 (two per module) threaded onto the strap 5 which attaches around the drop center of the wheel and is held tight with grommet 6. Although not shown in the drawing the underside of each cleat has a high friction surface to resist assist in preventing the transponder from slipping and moving from it installed location.

Drawing 05 is a close up vie of the WAMS transponder showing the main module 2, tapered power module separator 3, power module 4, sensor module 8 and tapered sensor separator 9, and mounting cleats 10.

Drawing 06 shows an exploded view of the major components of the WAMS transponder. The sensor module housing 11, sensor electronics 12, tapered sensor separator 13, housing for the main module 14, main module electronics 15, tapered power module separator 16, power module battery insert 17, and power module housing 18. Other features shown are the sensor module multi-pin plug 19, tapered sensor separator socket 20 and matching multi-pin plug 21, main module multi-pin socket 22 and socket 23 for power module attachment (in this case for the tapered power module insert), tapered power module separator plug 24 and socket 25, and power module plug 26.

Drawing 07 shows an angular exploded view of the complete WAMS transponder providing a better view of the interconnect design.

Drawing 08 is a view of a flat sensing transponder without the use of tapered separators. In this application the power module 4 and sensor module 8 each plug directly into the main module 2. The attachment cleats 10 can still be used for connection to the host.

Drawing 09 is an exploded view of the flat sensing transponder again showing power module housing 18, power module battery insert 17, housing for the main module 14, main module electronics 15, sensor electronics 12 and the sensor module housing 11. Other features shown are the sensor module multi-pin plug 19, matching main module multi-pin socket 22 and socket 23 (for power module attachment) and power module plug 26.

Drawing 10 is view of the basic transponder consisting of the power module 2 plugged into the main module 4. In this case a snap cap 27 is used to seal the unused sensor module socket. There are several versions of this cap, one being a snap on cap used only for sealing purposes, and the others are using for setting certain transponder operating conditions. For example, the main module's hybrid transmitter can be operated in either an OOK modulation mode or ASK modulation mode. The appropriate cap is attached to achieve the selected modulation mode. It can be removed and replaced with the alternate cap version if the modulation method needs to be changed. All of the sensor modules and other special custom attachments have the same modulation setting option.

Drawing 11 is another exploded view of the basic transponder again showing power module housing 18, power module battery insert 17, housing for the main module 14, main module electronics 15 and the selected end cap 27. Other features shown are the end cap multi-pin plug 19, matching main module multi-pin socket 22 and socket 23 (for power module attachment) and power module plug 26.

Drawing 12 is a close up view of the power module 2 showing more detail of the attachment features. A later drawing will show the double latching feature. In addition to showing the plug 26 and attachment cleats 10, the drawing shows the interlocking tongue 28 that fits into a groove on the mating parts to provide a watertight connection.

Drawing 13 is an exploded view of the power module showing the housing 2, attachment cleats 10, and battery insert 17 and plug 26. The drawing also shows the sealing bullhead 29 that is present on all module inserts.

Drawing 14 shows a typical tapered separator 25 in detail. The plug 24 and socket 25 match either the power module connection to main module connection, or the sensor module to main module connection. Also shown are the tongue and groove features 28 that provide a water-tight assembly. Not shown in the drawing is the double latching feature for the power module separator. All module attachments on the sensor end of the main module include a single-latch feature that allows for non-destructive removal and replacement.

Drawing 15 shows close up view of the main module 4 containing the micro-controller, RF transmitter, polling circuit, temperature sensor, battery condition monitor, transmit inhibit switch and poll response LED. It shows the sensor interface sockets 20 and 23, cleats 10, and the sealing tongue 28.

Drawing 16 is an exploded close up view of the main module showing its case 14, attachment cleats 10, electronics PCB 15, socket 20 and 23, and the sealing bulkheads 29.

Drawing 17 shows close up view of the sensor module 8 showing the plug 19 that interfaces with the main module, cleats 10, and the sealing tongue 28.
Drawing 18 shows an exploded close up view of the sensor module showing the case 11, electronics PCB 12, plug 19 that interfaces with the main module and the sealing bulkhead 29, cleats 10, and the sealing tongue 28.

Drawing 19 shows the basic transponder (power module and main module) and a ribbon cable 30 plugged into the sensor interface socket 22. This cable serves a variety of purposes that include programming the micro-controller, testing the main module functionality including setting the modulation method to either OOK or ASK, or to interface sensors. In an actual installation where the transponder is connected to external sensors, the plug would be built into an end cap to provide a sealed assembly.

Drawing 20 shows the power module 2 connected to the main module 4, showing the cable and plug assembly 30 before insertion into the sensor connection socket 22.
Drawing 21 shows the main module 4 in a further test configuration where the power is also supplied through a plug in cable 31 allowing a complete in process test of the main at various voltage levels and to measure current drain in various modes and conditions of operation, and with various sensor loads. The main module alone, or with any form of sensor connection, can also be powered from an external source used this power cable connector but the plug would then be built into an end cap to provide a sealed assembly.
Drawing 22 shows the main module with the two unplugged cable connectors 30 and 31.

Drawing 23 shows a view of the assembled, fixed LITMIS PC-104 Reader 50 with mounting flange 51. Also shown is the dual PCMCIA slot 52, serial connector 53, power connector 54 and LAN connector 55. Also shown are ten coaxial connectors, one for a WLAN antenna 56, one for a GPS antenna 57, and eight connectors 58 providing coax cable connections to the maximum number of four, dual (orthogonal) antennae.

Drawing 24 shows an exploded view of the fixed LITMIS PC-104 Reader showing the case 60, the cover 59 and mounting flanges 51, the dual PCMCIA slot 52, serial connector 53, power connector 54 and LAN connector 55. Also coax sockets 56, 57, and 58. The four PC-104 boards shown are PCMCIA two-slot Module 61 that can be used for GPS or 802.11 cards or even one of two LITMIS PCMCIA Readers (such as Aaeon PCM-3115B), CPU Module 62 (such as Aaeon PCM-4335 or 3336), Ethernet Module 63 (such as Aaeon PCM-3660) and the LITMIS Reader 64. Other PC-104 options include a Vehicle Power Supply Module for Wheel and Axel Monitoring Systems, fork lift, golf cart or similar applications, 48-channel DIO Module such as Aaeon PCM-33724),

Isolated RS232/422/485 Module (such as Aaeon PCM-3610), or a Cell Phone/Internet Communications Board (including boards such as Ubicom's PhantomServer). All these are either alternates to the Ethernet Module or the stack can be expanded to include multiple options.

Drawing 25 shows the Power Module and Main Module latching mechanism not show in previous drawings. The object is allow the module to latch mechanically but not electrically, and then be further pressed together into order to establish a complete latching of the two modules providing a power connection and a water tight sealed closure. The drawings (from top to bottom) show the power module latch 01 aligned against the main module receptor 02. The power module latch is a cantilever beam 03 with a pin 04 at the forward end. The receptor has a ramp 05 that pushes the cantilevered pin up as the modules are pressed together, until the pin can drop in a matching (blind) slot 06, mechanically latching the two modules together as show 07. On pushing the two modules further together a second ramp 08 pushes the cantilevered pin up 09 until the pin can drop in a second matching (open) slot 10. At this point the main module is powered and both modules sealed. To unlatch the modules and disconnect power, an unlatching probe 11 can be inserted into the hole 12 providing access into the second slot and thereby push the latching pin of the power module up enough to clear the top of the ramp and thereby separate the power and main modules until the power module latching pin again drops into the first slot. At this point the modules cannot be separated without breaking off the cantilever at 12 from the power module. In this manner, spent power modules cannot accidentally be reinserted into a main module assuring that only new, unused power modules will be attached.

Drawing 26 shows the Sensor Module latching mechanism 01 and Main Module (sensor) receptor mechanism 02 not show in earlier drawings. In this case there is only a single latching ramp 03 that is equivalent to the second latch function of the power module, the pin dropping into slot 04 to complete the locking process. The two modules can be separated as before by using an unlatching probe 05 to push the cantilever pin (through access hole 06) up over the top of the ramp 03 and pulling the two modules apart.

It should be noted that between prior to removal and insertion of a new sensing module or alternate data attachment, the transponder main module will likely need to be reprogrammed to match the requirements of the new module. This is done using the ribbon connector that is plugged into the same location as the sensor module (although the connector pin assignments will be different).

Drawing 27 and 28 show the means by which the test, programming and external sensor cables, and any plug in sensor or special purpose module, include connections that select whether the Transponder transmits an OOK modulated signal or an ASK modulated signal, further adding to the versatility of the LITMIS product that allows field programming and field configuration, in order to optimize the system's performance for each application. In drawing 27 the transmitter hybrid TX5000 01 can be connected either to operate in an OOK modulation mode or an ASK modulation mode depending on whether the transmit enable connection from the micro-controller is connected to the

TX5000 pin 17 or pin 18 (the unconnected pin is grounded). To achieve this for OOK modulation the connection (cable or module) to the main module 06 has four of its pins connected so that the main module connections 02 and 03 are connected (grounding TX5000 pin 17) and connections 04 and 05 are connected (connecting TX5000 pin18 to the micro-controller Transmit enable pin). Drawing 28 shows the ASK modulation where the connection (cable or module) to the main module 06 has four of its pins connected so that the main module connections 02 and 04 are connected (grounding TX5000 pin 18) and connections 03 and 05 are connected (connecting TX5000 pin17 to the micro-controller Transmit enable pin).

Alternatively this concept can be used at the other end of the main module in which case the battery or cable power connection would be configured to select OOK or ASK modulation.

Drawing 29 shows the Transponder main module circuit schematic with the micro-controller part 01, the transmit hybrid TX5000 part 02, and the polling receiver 03 consisting of the tuned circuit L4 and C7, rectifier D2 and load R4. The temperature sensor 04 consists of Q1 and R5, and a polling reception indicator 05 consists of LED D1 which is also a means of determining battery condition by reading the voltage at the node between R3 and D1 at the micro-controller pin 2 via R6 when the LED is turned on by the polling reception signal. The micro-controller (PIC16LF876A or equivalent) also has built in temperature sensing and battery condition monitors but when other micro-controllers are used to optimize performance that do not have these features these alternate options are available, or they can be used to provide an alternate input on these parameters.

Drawing 30 is a block diagram of the basic LIMIS Reader. The RF Section consist of an RF Receiver with connectors for one or two (for diversity) antenna, an antenna-receiver impedance matching circuit and a OOK/ASK receiver. There are two identical RF sections per circuit as shown in this drawing. The Analog Section has a gain circuit that consists of a differential amplifier and a summing amplifier. The differential amplifier provides gain and offset adjustment while the summing amplifier adds the two (1 per receiver) signals together. The Analog Section also has a filter circuit consisting of an active filter reduce signal noise. The Digital Section has a level detector consisting of a 16 level voltage divider, 16 comparators and a upper and lower level voltage adjustment. The voltage divider provides 16 equally spaced voltage reference levels for the 16 comparators. Each comparator detects if the received signal is high or lower than its voltage reference. The upper and lower voltage references are adjusted using a potentiometer. This Level Detector serves to provide a calibrated 16 bit Signal Strength functions with the range sensitivity being controlled by the 32-bit processor.

The CPLD functions consist of a 16 level to 4-bit converter that de-bounces the incoming bits and converts the data to a 4 bit binary code. A Digital Squelch function is used to set a minimum signal value. Any signals below the digital squelch level are ignored. The Digital Filter performs a weighted average on the signal. Each sample is weighted based on the age of the sample, and the older the sample the less weight a sample has in the

average. This provides a smoother signal and reduces noise. A Slope Detector looks for slope changes in the signal. There are currently 3 types of slopes detected (up, down & level). Any change in slope type is detected and a pulse is generated. An 18-bit counter is used to keep a rolling count of the 4MHz clock in a binary format. A Time Stamp Latch latches whenever a pulse is latched from the 18-bit counter whenever a pulse is received from the slope detector. All roll-over events are also latched to aid in tracking event timing. All data captured in the time stamp latch is also loaded into a 4K x 18 bit FIFO (First In First Out) Memory device. The FIFO is used to store time stamps until the micro-processor is ready to read them. Event Rate Detector is used when time stamps occur at a rate that is faster than the known signal rate, it makes an automatic adjustment to the digital squelch circuit which effectively eliminates fast noise signals. The microprocessor reads data from the FIFO and analyzes the time stamps to decode data from the transmitter. The microprocessor also controls the potentiometers that adjust the upper and lower threshold levels. The microprocessor also sets the level in the digital squelch circuit, and acts as the interface to the system computer. Drawings 31 to 40 show the Reader Board detailed circuit schematic and drawings 41 to 48 the reader PC-104 board layout.

Drawing 49 describes a method for rapidly switching four pairs of orthogonal antennas. The antenna pairs provide diversity when the Transponder exhibits directional transmission characteristics. The objective of the four pairs of antennae is to provide the ability to accurately locate transponders without having to have four times as many Readers. The four pairs of antennae can either time-share the dual the receiver (one pair at a time) or all eight antennae can time-share a single receiver, the version shown in Drawing 49. The heart of each switching circuit is a PIN diode, that provide a switching time of less than 10nS with the throughput loss of less than 0.1dB at 433MHz.

Drawing 50 shows the outline of many configurations of transponder each having the standard main module 01 (with appropriate firmware) and the standard power module plug-in 02 (or external wired power plug, not shown in this drawing). Item 03 is the cap seal which may only serve the purpose of selecting the OOK or ASK modulation and sealing the sensor connector end of the main module. Item 04 is the external sensor connector which also serves the purpose of selecting the OOK or ASK modulation and sealing the sensor connector end of the main module. Item 05 is a plug-in pressure sensor module which also serves the purpose of selecting the OOK or ASK modulation, that latches into and seals the sensor connector end of the main module. Similarly 06 is a wheel monitoring module which can also have a vibration sensor or accelerometer and would in this application require the tapered inserts referred to earlier; 07 is a GPS module to provide location data for transmission to the Reader; 08 is a location identifier with an RF receiver that receives a polling signals from an assigned location triggering an immediate transmission to the Reader; 09 is a directional antenna transmit module that is used with a matching very directional receive antenna to provide floor by floor location of transponders; 10 is an RF receiver with a very directional receive antenna that receives un-coded polling signals from an assigned location that has a very directional antenna so as only to poll transponders on the same floor; 11 is a location identifier with an RF receiver that receives and decodes coded polling signals from an assigned location for

adding to the transponder unique code before transmission to the Reader; 12 identifies two completely different modules one being a GPS module providing location data for adding to the transponder's unique code before transmission to the Reader and the other is a fixed frame module that provides video data to add to the location data for adding to the transponder's unique code before transmission to the Reader, this is shown as one transponder because in some police applications both functions would be implemented in the same product. Other transponder configurations 13 for use in water analysis in pools and ponds, 14 is a module that can receive extremely directional polling signals that may be laser, light, infrared, ultrasound or audio-modulated directional ultrasonic transmissions, that can provide very accurate timing of the reception of the polling signal. In fact the polling signal can be coded with a accurate timing information for use in event timing like motocross or auto racing. Magnetic sensors 15 can be used for sensing motion, orientation, attitude or proximity to a magnetic source, even being able to sense door opening and how much the door is open; one example of an external sensor 04 is a switch that identifies whether a door is open or closed which can trigger a reader to identify changing inventory is a storage facility or cargo container. Other sensors shown are 16 which can be attached to a radiation containment vessel or a person to detect radiation levels, olfactory (drug/odor) sensing 17, and explosive material sensing 18 all of which (as in other applications) can be monitored by the transponder, compared with established limits and evaluated against previous readings to determine rate of change, this can be programmed into the transponder so as to modify the transponders sampling rate, transmission periodicity and even transmission power. Similarly when this information is received and decoded by the Reader, the Reader's response in terms of providing alarms, communication to cell phones and communicating by E-mail can be implemented according to programmed instructions – these are features of the Reader discussed elsewhere.

Drawing 51 illustrates some of these sensor and communications concepts showing 01 the power module and 02 the main module; 03 is the end cap; 04 the various internal sensor modules; 05 an RF receiver (or two-way communication module); 06 a floating water condition monitor; 07 a soil moisture probe, 08 an external sensor connector; 09 is a GPS module, or other satellite based transmitter 11 (shown in orbit 12) receiver module. Module 10 and 13 provide two-way ground communication between transponder and a communicating unit. 14 identifies a Reader with a radio link (or wired LAN or other wired link not shown) to a central control PC 16 or a radio link to a handheld PDA 17 which may be using 802.11, cell phone, internet or other communication method. Item 15 is a handheld unit (such as PDA) which contains both a receiver (in the form of a serially connected PCB or a PCMCIA card) that can then communicate to a base unit 16 or another PDA 17 using 802.11 or other communications.

Drawing 52 shows diagrams of possible designs for transponder plug-in sensors; 01 shows a moisture testing probe that can be pushed into the soil and the tip of the probe has "pores" which allow a moisture sensor inside the probe to obtain a reading of relative moisture level. The transponder main module with it power module is simply plugged into the probe connector which includes the standard OOK or ASK selection function, and other standard interconnections between sensor modules and the main module such

as power and data lines, as well as the standard latching and sealing mechanisms. The floating pool sensor consists of a float 02 and a sensing unit 03 on the end of a "snorkel", where the sensing unit can contain a variety of elements to monitor pH, Chorine content, hardness and sensors that evaluate the water for possible dangerous contaminants. Although not shown, the multi-parameter sensing unit could be built into the water filtration system in which case the transponder would simply snap on to it in a similar manner to the moisture probe. An alternative form of the floating sensor would include a motion or vibration sensor (accelerometer) inside the submerged housing 03 that would provide information on momentary or sustained turbulence that might indicate something had fallen into the pool such as a small child or an elderly person. Item 04 is a typical security sensor that detect movement of people of objects in its vicinity but designed as a plug-in transponder module; 05 is a module that picks up polling signals; 06 monitors the status (open, open by how much or closed) or changing status (opening or closing) of doors, windows, containers, mail boxes, safes, vaults, etc; 07 represent safety monitors such as heat, fire, smoke, allergens and the presence of other harmful conditions designed as a plug-in transponder module; 08 a radioactive sensor , 09 a wind velocity sensor, 10 a rain gauge and 11 a blood pressure or pulse rate monitor. This latter application can be expanded to include anything monitoring life signs of chronically ill patients, particularly ambulatory patients who may not be under the constant care of another individual.

Drawing 53 shows the nature of a Receiver 01 connected an antenna array using four pairs of orthogonal antennae 02 located in directions perpendicular to each other, at equal distances for the Reader determined by the Read range of each antenna. The dotted circles 04 are intended to represent four of the sixteen Signal Strength Identification zones. The Reader is typically located just within the maximum range of each Antenna.

Drawing 54 shows the nature of a Receiver 01 connected an antenna array using eight single antennae 02 located in directions at 45 degrees to each other, every alternate one in a circle are at equal distances for the Reader, the distance of the nearest set of four is determined by the Read range of each antenna, and the distance of the furthest set depends on the degree of coverage required. The sets of four antennae show are all the same type of antenna, but each set could be antennae having different gains or characteristics. In side building or in odd shaped areas to be monitored, each of the eight antennae could have different characteristics or performance. The dotted circles 04 are intended to represent four of the sixteen Signal Strength Identification zones. The Reader is typically located just within the maximum range of the nearest antenna. In this case of arraying eight independent antennae all eight antenna need to be identified (as to the source of the signal) by the Reader's micro-controller. Drawing 55 is an exploded view of a sensing transponder.

APPLICATIONS

The breadth of systems applications that can be covered by the modular, re-programmable, multi-sensor options of the transponder and the ability to deliver the received information to remote locations, particularly involving cell phone and internet connection is the innovative aspect of the invention. In many cases the Transponder

itself, or the Reader or central computer could allow monitoring of selected sensed parameter for a period of time while it "learns" what the typical variation of that parameter is and establishes normal maximum and minimum values for it. After that period of time the system would only notify the owner (or designated overseer) when a value goes outside that acceptable range.

For example: Residential Monitoring

1. Monitoring Electricity Usage (abnormality indicating lost of power or a short)
2. Monitoring Natural Gas Usage (abnormality indicating a lost of service or a leak)
3. Monitoring Water Usage (abnormality indicating a lost of supply or a leak)
4. Monitoring Fluid Level in Fuel Oil or Gas storage tanks (indicates order needed)
5. Monitoring Temperature (abnormality indicating a lost of heat or air conditioning, or a fire or appliance/oven/hot plate left on)
6. Monitoring Humidity (abnormality indicating a medically required humidification system malfunction)
7. Monitoring Allergens (abnormality indicating a potential medical risk from excess pollen, dust, bacteria or other air born particulates or contaminants)
8. Monitoring Light Level (abnormality indicating lights left on or the sun is up)
9. Monitoring Noise Level (abnormality indicating dog barking, something breaking or phone ringing)
10. Monitoring Pool or Pond Water Level (abnormality indicating overflow or water needed)
11. Monitoring Pool Water Condition (abnormality indicating pH, Chlorine, hardness and contaminant problem)
12. Monitoring Pool or Pond Water Agitation (abnormality indicating something or someone fell or jumped into the pool, or there is a strong wind or an earthquake)
13. Monitoring Fish Pond Water Quality (abnormality indicating lack of Oxygen, presence of poisons or other contaminants)
14. Monitoring Soil Moisture Level (abnormality indicating failure of irrigation to expensive newly planted trees or broken line causing flooding)
15. Monitoring Lawn Moisture Level (abnormality indicating failure of irrigation or jammed sprinkler head)
16. Monitoring Rainfall/Snowfall and rate of precipitation (abnormality indicating a need for taking some action – perhaps turning off the sprinkler)
17. Monitoring Wind Speed/Gusts (abnormality indicating a need for taking some action – take down awnings and implement damage control)
18. Monitoring Density of Wooden Rafters and Studs (abnormality indicating possible infestation of Termites or Wood eating beetles)
19. Monitoring Freezer/Refrigerator Temperature (abnormality indicating failure and risk to food and perishables)
20. Monitoring Vehicle Tire Pressure from inside the house (abnormality indicating overnight air leak)
21. Monitoring Vehicle Fluid Levels from inside the house (abnormality indicating a need for coolant, fuel, oil or brake fluid before driving off)

22. Monitoring Solar Heating/Power Generation (abnormality indicating a system failure requiring attention)
23. Monitoring Elderly or Chronically Ill Patients (lack of movement or a fall indicating a need for checking on them, even monitoring blood sugar, pulse, etc.)
24. Monitoring Mail Box Opening (indicating delivery of mail, illegal removal of mail and mail box destruction)
25. Monitoring Circuit Breakers (indicating tripped breaker, perhaps an alarm failure)
26. Monitoring Weight or Load (abnormality indicating overload or over stressed condition)
27. Identifying Movement (sensing of invaded premises or unauthorized presence)
28. Identifying Open Doors or Windows (sensing a young child getting out, teens arriving home at night, a door or window left (or blown) open, garage door open)
29. Identifying Security Breeches (sensing a safe or security vault being opened, or a secure area being entered, or an valuable item being removed)
30. Locating Items, People or Pets (integrated into a single monitoring system)

Similar sets of applications achievable with a single installation include commercial offices and workplaces, warehouses and factories, manufacturing plants and power stations, maintenance depots, theme parks, underground mines, military deployments, marshalling yards, airports, docks, vehicles, planes, ships and in fact in any situation where a combination of Location, Identification, Tracking, Monitoring, Interrogation and Sensing functions are required and particularly where real time notification of persons remote from the site is required. The major feature of this innovation is the ability to accomplish all of the above functions with a single modularized, post-programmable design that can deliver that information from anywhere to anywhere instantly. The firmware in transponders can be re-programmed in the field and software in the Readers can be re-programmed through a wide choice of wired or wireless options.

UNIVERSAL RADIO LOCATION, INTERPRETIVE MONITORING AND EVENT TIMING SYSTEM AND METHOD

John J. Coulthard

Abstract

The system consists of three categories of plug-in systems components, Transponders, Readers and Pollers that are modularized and re-programmable to allow configuration to meet a variety of customized applications providing Radio Frequency Location, Identification, Tracking, Monitoring and Interpreted Sensing Functions. The Transponders have modularized components including a power module, a micro-controller module with a polling receiver, a family of sensor/communication/interface modules, and configuration and attachment hardware. The Pollers which have a limited range can wake up a Transponder that comes within its vicinity and provide simple keying or coded transmissions to cause the Transponder to transmit its stored data immediately as well as provide Poller location information such as GPS coordinates that can be relayed by the Transponder to the Reader. The Transponder also has the ability to store data, determine normal conditions, interpret variations from normal conditions and modify its sampling and transmission periodicity as appropriate. The Readers consist of PCBs that can be integrated into PDAs or PCs, PCMCIA Reader cards that can be used with any computer having a PCMCIA slot, and Readers with an embedded computer that have communication links such as LAN, WLAN, Cell Phone, Internet and radio. All of the processor based system components are customer programmable and can be interchanged between applications in the field. A single Reader can be programmed to receive and decode any combination of Transponder configurations that may be within its reception range at any time.

BACKGROUND OF INVENTION

The present invention relates to apparatus and methods that can be used in a wide variety of applications such as remotely locating, identifying and tracking people, items, vehicles or other objects particular the time they pass a certain location, or can be configured to monitor and interpret a variety of sensed parameters. This enables the product to be configured for use in event timing such as cross country racing, selective surveillance, deliveries, entries or access to such items as containers, vehicles, crates and other locations. More generally the invention relates to apparatus and methods that utilize sensors, coded polling transmitters, micro-controllers that analyze and store unique encoded data, can receive data and instructions from remote sources, and can transmit this information to readers that receive, decode and present the information for review, analysis and the determination of appropriate action. Furthermore with the ability to send emergency information immediately on the SMS Data Channel of Cell Phone communications or summary data over the Internet, any sensed or monitoring information can be delivered in real time to anywhere in the world, all with a single reader or with an arrayed set of identical readers.

Many systems exist that provide some specific function or functions described above but none have achieved the degree of standardization or universal applicability that enables a system to be customized to meet certain application requirements without the need to develop new and untried hardware variations or that can be integrated into a common information collection system. This can only be achieved by a concept that addresses the nature of mechanical versatility, functionally modularity, real time programmability and environmental adaptability. A hardware system and method that is essentially application independent but can be constrained to specific applications, to the extent necessary, by solution providers who incorporate appropriate custom firmware and software.

The most critical aspect of the invention is the modularized nature of the Transponder and its mechanical and functional versatility. It consists of three primary elements, two of which are common to all applications and environments described previously. They are the power module and the main module that contains a micro-controller and the RF communication circuitry. These two modules are sealed and plug together to achieve an electrical link. The main module has connectors on both ends. One end is used both for programming and testing using a ribbon connector. In use it is the end to which the power module it attached. The connector at the other end is used for testing and selecting certain functional options such as transmitter modulation mode, pulse widths and frequency, and is also used to plug in the third module. The third module can have a variety of features from simply a sealed cap that selects the transmission characteristics and protects the connector when used only for beacon applications, to a wide choice of active sensing and communicating modules, that can range from GPS and Fixed Frame Video, to Wheel and Axle Monitoring that includes pressure, temperature, acceleration and acoustic sensors: to a custom connector module for interfacing with customer provided sensors and to electronic systems that provide a variety of telemetry functions.

Another key feature of the system is the means by which transponders configured for the complete range of possible applications from any sensing function to real time inventory tracking, from vehicle wheel and axle monitoring, from GPS position location identification to fixed frame video surveillance, can all be read together using the same Receiver. This is possible because the transponder for all these applications is the same except for the special purpose module, and the data encoding is the same for all transponders except for the word length and the nature of the encoded information. The Universal Coding Format used in the Transponder's transmission contains information needed by the decoder to recognize the data as coming from a particular transponder configuration. The Universal Coding Format provides information regarding the type of the transmission encoding scheme (Transmission Type Code), an application specific group code, a unique transponder code, a polling code, and a variety of event status or sensor data bytes, which can each have a different number of bits, or even none at all. The nature of the encoded information is programmed into the Reader software as a look-up table and identified through the transponder's individual code.

The polling scheme can have a variety of features depending on the nature of the application. Either it is a simple signal that wakes the Transponder up in order to have it send its information immediately instead of at its normal periodic rate, or it is coded to be

responded to only by a specific Transponder, or for a another purpose such as a timing or location purpose. In this case it is important that the polling transmitter has only a limited range so as only to address those Transponders at a particular location such as scoring line in racing or a doorway in a building. In this case the Transponder microprocessor will append the polling code to the Transponder's unique code and immediately transmit its complete message. In many applications there may be a significant number of Transponders within the range of the polling signal (such is racing events) and there the polling scheme needs to include a varying delay between Transponders to avoid a significant increase in the probability of transmission collisions. This is accomplished by introducing a varying delay before a Transponder sends its message, a delay that is preprogrammed into the Transponder's memory. This can be achieved either by storing a polling transmission delay in the microprocessor program, or an instruction to derive the delay of a certain number of clock cycles from the Transponder's unique code. Since the magnitude of the delay between Transponders needs to be a function of the message length and that varies from application to application, the Transponder's microprocessor also needs to derive the size of the delay increments from the message length of each Transponder's transmission or alternatively from a look up table linked to the Transmission Type Code.

The transmission scheme is set up to have a maximum bit count for each byte, which may be different for each byte, and a maximum byte count for each word, which may be different for each byte. In addition there may be a different number of words in each Transponder's transmission. There are only a specific number of different transmission schemes that are defined by The Transmission Type Code, which is programmed into the Reader's memory as a look up table.

The Read can be embodied in a fixed format, typically using two receive channels for diversity or for a PDA application a single receive channel either integrated into the PDA using a serial interface or as a PCMCIA card. In the latter case the PCMCIA card may be implemented using a PCB thin film radiator on the card serving as the antenna, or a Splatch commercial networked antenna, or an external stub or whip antenna. All three versions have been build and tested. The external antenna version includes end connectors on the PCMCIA card, an MMCX connector for the antenna a 4-pin connector for programming and a 15 pin connector for testing or use in a serial output mode. The fixed Reader can be implemented in a PCI format for integration into a PC, a PC-104 format for use with an imbedded processor in a PC-104 styled Reader, or a dual PCMCIA slot PC-104 board can be used and the external antenna PCMCIA card simply plugged into one slot. The second slot can either be used for a PCMCIA modem for transmitting information to a control center by RF or to phone jack, or it can be used for a second PCMCIA Receiver card to provide diversity. In the case of high gain antenna(s) requiring low loss cable connections, a bulkhead connector(s) would be provided on the Reader case for that connection and a micro-coax cable(s) would connect from the bulkhead connector(s) to the PCMCIA MMCX connector(s).

The Reader has a 16-bit attenuator ahead of the RF Receiver which with a wide choice of antennae from ¼ wave Helical antennae to high gain Yagi antenna can be used to limit

the range of Receivers both at the installation stage as well as by instructions delivered by the two-way wired or wireless Reader communications link.

One embodiment of the technology involves the use of the Transponder in its polling mode. A short range coded polling transmitter with a directional antenna is located at each timing location. As the Transponder comes within range of the polling transmitter it receives the polling signal which wakes up the Transponder, that then extracts the polling code, appends this code to its own unique code, and immediately transmits the information to the Reader after which it returns to its sleep mode.

Another mode of operation of the system is for the Transponder, in addition to the functions described previously, also sends out a very narrow low power beacon pulse every tenth of a second to every second, depending on the application, except when it is sending data to the Reader. This pulse is ignored by the Reader but can be read by a Responder that is a pollable Poller. In other words a Poller that only transmits a polling signal when it receives this beacon prompt. The responder then sends a short range communication to the Transponder in a similar manner to the Polling method described above. In this case the Responder communication may contain significantly more information or instructions than the Poller, which is why the system is designed to limit the Responders transmissions to cases where a Transponder is identified as being within range. This increases battery life and reduces the potential for data collisions. The Responder's transmission my contain only an identity code as in the case of the Poller or it may provide detailed instructions that modify the behavior of the Transponder for a period of time before returning to its normal mode or until given new instructions by a subsequent Responder. The Responder's data may instead, or in addition, contain information that the Transponder is requested to pass on to the Reader. It should be noted that this system can be implemented either with a moving Transponder and a fixed Responder, or a moving Responder and a fixed Transponder, or they can both be moving. There are applications where one's location may be fixed and the other may normally be stationary but is moved periodically to another location. The Responder is typically programmed to transmit once (perhaps with three consecutive messages) and then shut down, resetting when it no longer receives beacon prompts. An example of the latter is the placement of a container in a storage vault, the Transponder receives the storage vault's location code from the Responder as it comes within range, then attaches this storage vault's location code to its own until it is moved to another location. The Responder would not continue to "instruct" the Transponder after its initial transmission

Other examples of modified Transponder function include modifying limits depending on the location or local environment such as inside or outside a building, above or below ground, or on the ground as above ground. For example, when inside a plane the Transponder may be instructed to shut down its transmission until it leaves the plane except perhaps if it has detected an emergency situation. In this case the sensing function would have to have been left functioning.

There are a number of safety and security situations where a Transponder's host has entered a sensitive area and its monitoring and/or transmission periodicity needs to be

modified, or transmit power changed, or in the case of a Transponder with a programmable transmitter frequency, the frequency needs to be changed.

The Transponder may have a sensor that is only to be used in certain situations or types of location, or shut off in a particular environment. For example, a child being monitored ina house might not have an emersion sensor functioning normally but it would be turned on when the child entered a bathroom or the vicinity of a pool or pond. The Transponder may be required to send out an audio signal or flash a light or transmit in some other medium when in the vicinity of a certain situation.

The Reader is capable of receiving Transponder transmissions from a distance of up to 1500 feet depending on the nature of the receiving antenna. The Reader on receiving a Transponder's transmission then extracts the Transponder's unique code and the polling code, and time stamps the entry. This provides real time information on the identity of the tagged person or item, and the time it passed a specific timing location. One Receiver can cover an area having a radius of 1500 feet and can monitor a large number of people or items without risk of collision errors because the Transponders only transmit as they pass a timing location. The short range of the polling transmitter limits the number of Transponders responding to those within several feet of the timing location, although the system is capable of receiving transmissions from several hundred Transponders polled simultaneously.

Another embodiment of the system is to monitor conditions in a home or multi-room building with the objective in this case of identifying the initiation of conditions that may lead to a fire or conditions harmful to the occupants or the contents.

The system in this case consists of sensing transponders that can monitor selected parameters every few seconds, establish normal environmental standards and then recognize changes from the normal situation, analyzing the data provided by the selected sensors to arrive at a determination of projected future events. The transponder, when in a stable environment, transmits its data to a Reader located centrally in the building, every five minutes, every hour or even every day to confirm transponder operation. However, if the transponder identifies abnormal readings or abnormal changes it can speed up its transmission periodicity providing rapid updates of absolute reading and rate of change of those readings, the behavior modification depending on the comparison of data to pre-programmed limits. The nature of the changing conditions may warrant a warning, an alert or an alarm depending on the seriousness of the predicted event.

One application for this method of operation is the monitoring of heart action for heart patients, newborn babies, the elderly and the chronically ill. The procedure would be to identify the timing and the amplitude of EKG waveforms. Each EKG heartbeat has four positive-going voltage changes, two transition from below and cross zero volts, the phase of these two different wave sections is also important and a fourth is the start of a second heartbeat waveform. Each heartbeat has three positive amplitudes. The Transponder would take samples of three consecutive peaks for each of the three peak amplitudes of interest and average the values for each peak. It would repeat this process after a short

delay and then repeat the process for a third time. These three averages would be stored along with the average of these averages. The same process would be implemented for the timing of these peaks. Having established a norm for these EKG waveforms this information would be periodically encoded and transmitted to a Reader board in a central computer. In addition the Transponder would compare new averages and rate of change of averages with preprogrammed limits. In the event any reading fell outside these limits then a rapid or continuous transmission of this data would be made. A further procedure could be to compare the three peak amplitudes or the timing of the three peaks or compare the peaks and the timing with each other. Since the Transponder can also be monitoring pulse rate, blood pressure and other life signs these can also be included in the analysis and compared with a doctor's designed set of limits and action decisions.

Examples of data that can be monitored are: The amplitude of R, the time from the moment the positive-going edge of R crosses zero, (a little after Q) to the time the positive waveform T returns to zero, and the time from the moment one positive-going edge of R crosses zero to the same place on the "next" waveform R. The EKG Transponder (PCB) may also include a clock, counter and timer, zero-crossing detectors, phase-angle detectors, comparators, amplitude measurements, memory and analog to digital coding. Since "spike" R has the highest (steepest) phase angle and amplitude of the three positive wave sections in a heartbeat, this zero-crossing and steep phase-angle (representing part of a "high" frequency waveform vs the "low" frequency of the P and T waves) combination be used as a start time. See above. The negative-going wave sections from this time can be monitored and counted (Q->S continuing through T). From start time to when the second wave section T returns to zero is the second parameter. The amplitude of all positive waveforms can be sampled, stored and counted; if the second positive waveform also has the highest phase-angle and amplitude this is R and can be can be coded. See above.

The Eclipse circuit (Drawing ZZ) has an oscillator, timing, A/D converters, voltage reference, comparators, logic, and memory. It can also provide voltage or current to sensors. Each Eclipse can handle or control one analog input/detector at a time although as many as six with multiplexing.

The Reader can provide a local sound signal (as in a smoke alarm) and it can also dial up a phone number alerting authorities or can even send data to an Internet or E-mail address.

In a typical deployment of this system the transponders would likely be reading temperature, and sensing for certain combustion products and toxic fumes. The transponder would be able to analyze the level of temperature, its rate of change, the existence of combustion products and toxic fumes, and their rate of increasing concentration to arrive at a prognosis and determine a course of action based on its programmed instructions. With the transponders located in each room of the building, in the garage, on the patio, and at any high-risk locations, their collective input can provide information as to where a fire starts, have fast it is spreading, how hot it is, what the

concentration of certain toxic fumes are, what people are in the building and where they are located, all before the emergency crew arrive on site.

Since the data is transmitted in real time to an Internet address, even if the building and the system are destroyed, the data is still available for later analysis. The Reader can also be protected against fire.

DESCRIPTION OF DRAWINGS

Drawing 01 shows the Transponder main module circuit schematic with the micro-controller part 001 and the transmit hybrid TX5000 part 002. A polling receiver 006 consisting of the tuned circuit L4 and C7, rectifier D2 and load R4. A resistor network 003 provides the means for onboard selection of either OOK or ASK modulation by inserting zero ohm resistors R6 and R9 or R7 and R8 respectively. Alternatively, all four of these resistors can be omitted and off board modulation decision can be made with connectors J1-9 and J1-10, shown by 004. Circuit 005 and other J2 pins provide the ability for on-board programming or subsequent reprogramming. A simple polling receiver 006 consists of the tuned circuit L4 and C7, rectifier D2 and load R4 and a polling reception indicator 007 consists of LED D1 that is also a means of determining battery condition by reading the voltage at the node between R3 and D1 at the micro-controller pin 2 via R6 when the LED is turned on by the polling reception signal. Also an on-board temperature sensor 008 consists of Q1 and R5. The connector J1, 009, provides the connections to the power module or power ribbon cable and also provides the connections for on-board programming and testing. Connector J2, 010 provides connections for Transponder testing, modulation selection and where the application calls for it, connections to the sensor module, sensor ribbon cable or Receiver module for coded signals. Connector 011 provides a connection for an internal flexible whip antenna that wraps around the inside of the main module case or in some applications can protrude through a water tight slit in the case to provide improved range. The micro-controller (PIC16LF876A or equivalent) also has built in temperature sensing and battery condition monitors but when other micro-controllers are used to optimize performance that do not have these features these alternate options are available, or they can be used to provide an alternate input on these parameters.

Drawing 02 shows the layout of the topside of the Transponder PCB 012, the Modulation Selector/Sensor Module connector 013, and the Power Module/Reprogramming connector 014. A via, 015 (J3), is the flexible whip antenna connector.

Drawing 03 shows the layout of the bottom side of the Transponder PCB 012 showing the on-board OOK/ASK selection network 016.

Drawing 04 shows the transmission pulse timing when OOK modulation is used. The time slot 017 is 200uS wide and a "0" bit 018 is 40 uS wide pulse, significantly less than 50% of the time slot, while a "1" bit 019 is represented by four consecutive 40 uS wide pulses (one 160uS pulse) that is significantly more than 50% of the time slot. One example of the use of this transmission scheme is a byte than consist of a start bit 160, a

couple of sets of data bits 161 and 162, a parity bit 163 and two stop bits 164, all of this making up a word. The word may be transmitted several consecutive times (three in the example) in cases where the Receiver is required to identify a word two or three times before accepting the data.

Drawing 005 shows a diagram of the transmission encoding method. It shows a maximum of 80 time slots or bits, 030. Bit 1, 019, is the start bit and always a "one" followed by a five-bit byte, 020, that defines the Transmission Type, how many bytes make up the transmitted word and how many bits are in each byte. This is followed by a three-bit group code 021. These three "bytes" always make up the first nine bits transmitted. This is followed by the unique transponder code 022 that can be a byte with as many as 16 bits and a Polling code 023 with as many as 5 bits. Following this are five status or data bytes 024, 025, 026, 027, 028, each of which can have as many as eight bits. Following that there is a parity or CRC byte 029 that can have as many as 8 bits followed by two stop bits 031, both "zeros". The drawing shows the full eighty time-slots and the black fill shows the slots where there are transmissions. The white slots show no bits being transmitted and in the actual implementation these slots are eliminated, as shown by 032, 033, 034, 045, 036 and 037 that is why a preceding byte is needed to identify which bytes are included in the transmission and how many bits each has. This word will be transmitted several times with an interval in between that is determined by the word length and the specific nature of the application.

The polling 038 and data 039, 040, 041 bytes can consist of only one bit. In the polling case a "one" bit indicates that the Transponder is transmitting because of a polling instruction, a "zero" indicates that the Transponder transmitted according to its programmed periodicity (not polled). In the case of data bytes a single byte indicates status of a sensed input, zero or one (low or high), indicating that its monitored location is on or off, open or closed, above or below a limit, within a pair of limits or outside, or any other condition that can be represented by a single bit.

A polling byte 042 of more than one bit indicates the Transponder is transmitting because of a coded polling instruction and the byte represents that code. The Transponder can also be programmed without a polling bit at all and this indicates that the Transponder does not have a polling function. For other data bytes that have more than one bit, the byte represents actual data such as temperature, pressure, acceleration and humidity, or characteristics of a magnetic field, radioactivity, water quality, air contaminants or life signs, and information from thermostats, fire, smoke or security alarms. If less than five inputs are being monitored the "empty" bytes are eliminated. The Transmission Type Code includes information on the exact nature of each data byte, specifically what it represents and the bit to parameter magnitude relationship i.e. degrees per bit, psi per bit, gauss per bit, etc., and the range of that parameter. The byte can also be used to represent a variation from a "par" value or a rate of change.

Drawing 06 describes a Transponder Firmware Proposal for a specific Application.

Drawing 07 describes a set of Transponder Transmission Periodicity Decision Tables that show a Sensor Sampling Plan and Transmission Periodicity options that might apply to a Truck Wheel Monitoring application.

Drawing 08 describes a set of Transponder Transmission Periodicity Decision Tables that show a Sensor Sampling Plan and Transmission Periodicity options that might apply to Home and Building applications.

Drawing 09 shows a typical Transponder Firmware Flow Chart for a nominal application.

Drawing 10 illustrates the various Transponder configuration options such as Frequency, Modulation mode, Polling and Firmware options.

Drawings 11 and 12 show the means by which the test, programming and external sensor cables, and any plug in sensor or special purpose module, include connections that select whether the Transponder transmits an OOK modulated signal or an ASK modulated signal, further adding to the versatility of the LITMIS product that allows field programming and field configuration, in order to optimize the system's performance for each application. In drawing 27 the transmitter hybrid TX5000 01 can be connected either to operate in an OOK modulation mode or an ASK modulation mode depending on whether the transmit enable connection from the micro-controller is connected to the TX5000 pin 17 or pin 18 (the unconnected pin is grounded). To achieve this for OOK modulation the connection (cable or module) to the main module 06 has four of its pins connected so that the main module connections 02 and 03 are connected (grounding TX5000 pin 17) and connections 04 and 05 are connected (connecting TX5000 pin18 to the micro-controller Transmit enable pin). Drawing 28 shows the ASK modulation where the connection (cable or module) to the main module 06 has four of its pins connected so that the main module connections 02 and 04 are connected (grounding TX5000 pin 18) and connections 03 and 05 are connected (connecting TX5000 pin17 to the micro-controller Transmit enable pin).

Drawing 13 shows one form of a Sensor module where 043 is a temperature, which could be a thermistor, 044 is a bridge form of sensor that could be a pressure or a wide variety of bridge type sensors. The sensors are supplied by power from a voltage regulator 045 and the sensed voltages are amplified by operational amplifiers 046 and fed to comparators 047, whose outputs are delivered to the Transponder microprocessor.

Drawing 14 shows diagrams of possible designs for transponder plug-in sensors; 048 shows a moisture testing probe that can be pushed into the soil and the tip of the probe has "pores" which allow a moisture sensor inside the probe to obtain a reading of relative moisture level. The transponder main module with it power module is simply plugged into the probe connector which includes the standard OOK or ASK selection function, and other standard interconnections between sensor modules and the main module such as power and data lines, as well as the standard latching and sealing mechanisms. The floating pool sensor consists of a float 049 and a sensing unit 050 on the end of a "snorkel", where the sensing unit can contain a variety of elements to monitor pH,

Chorine content, hardness and sensors that evaluate the water for possible dangerous contaminants. Although not shown, the multi-parameter sensing unit could be built into the water filtration system in which case the transponder would simply snap on to it in a similar manner to the moisture probe. An alternative form of the floating sensor would include a motion or vibration sensor (accelerometer) inside the submerged housing 051 that would provide information on momentary or sustained turbulence that might indicate something had fallen into the pool such as a small child or an elderly person. Item 052 is a typical security sensor that detect movement of people of objects in its vicinity but designed as a plug-in transponder module; 053 is a module that picks up polling signals; 054 monitors the status (open, open by how much or closed) or changing status (opening or closing) of doors, windows, containers, mail boxes, safes, vaults, etc; 055 represent safety monitors such as heat, fire, smoke, allergens and the presence of other harmful conditions designed as a plug-in transponder module; 056 a radioactive sensor , 057 a wind velocity sensor, 058 a rain gauge and 059 a blood pressure or pulse rate monitor. This latter application can be expanded to include anything monitoring life signs of chronically ill patients, particularly ambulatory patients who may not be under the constant care of another individual.

Drawing 15 shows a water Quality sensor that could be used in a pool monitoring application checking pH, chlorine concentration, hardness, etc. This Sensing Transponder could also include a vibration sensor that could be used to monitor water turbulence. In this the Transponder would be programmed to sample and analyze to identify sudden changes in turbulence, typical of a person or animal falling into the pool and struggling to get out. The Reader would be programmed to distinguish between normal pool usage and unintended entry into the pool. Furthermore the system is designed to receive information from multiple sources and analyze relationships. Children or elderly people using a pool or likely to be in the vicinity of a pool or pond could have a wrist or ankle transponder with a submersion sensor that would provide further input, and a polling receiver that would provide location input when passing through a pool gate or leaving the house. Depending on how the Water Monitoring Transponder was situated in the pool it could also include a physical or magnetic pool level indicator.

Drawings 16 and 17 show heart beat characteristics that we be monitored by a transponder attached to young babies, the elderly or chronically ill patients, along with other important life signs. Each EKG heartbeat has four positive-going voltage changes to peaks 060, 063, 069 and 068, two transition from below and cross zero volts 063 and 069; the phase of these two different wave sections can also be recorded. The fourth 068 is the start of a second heartbeat waveform P. Each heartbeat has three positive amplitudes 060,063 and 069. These three analog parameters would be monitored and analyzed. In addition timing criteria 061, 064, 065 and the timing of the peaks 060, 063 and 069 would also be monitored. Sampling would establish norms for absolute values and the relative rate change of these characteristics, which when compared to absolute values, rate of change of values and comparison between characteristics as described in Drawing 08, anomalies requiring urgent attention can be identified.

In order to provide an effective interface between sensors of this sort and the Transponder

microprocessor when measuring heart beat amplitudes such as R, the time from the moment the positive-going edge of R crosses zero (a little after Q) to the time the positive waveform T returns to zero, the time from the moment one positive-going edge of R crosses zero to the same place on the "next" waveform R. This EKG Transponder interface module may also include a clock, counter and timer, zero-crossing detectors, phase-angle detectors, comparators, amplitude measurements, memory and analog to digital coding. Further since "spike" R has the highest (steepest) phase angle and amplitude of the three positive wave sections in a heartbeat, this zero-crossing and steep phase-angle (representing part of a "high" frequency waveform vs the "low" frequency of the P and T waves) combination can be used as a start time. The negative-going wave sections from this time can be monitored and counted (Q->S continuing through T). From start time to when the second wave section T returns to zero is the second parameter. The amplitude of all positive waveforms can be sampled, stored and counted; if the second positive waveform also has the highest phase-angle and amplitude this is R and can be can be coded.

Drawing 18 shows such an interface with an oscillator, timing, A/D converters, voltage reference, comparators, logic, and some memory that can also provide voltage or current to sensors. Each such interface can handle or control either one analog input/detector at a time; or with multiplexing up to six such sensors.

Diagram 19 shows a means for detecting the removal of a wrist or ankle Transponder sued in instances described above. The Transponder Module 070 is connected to the Power Module 071 by a conductor 072 which passes through a clasp 073 returns to and passes under 070 around the other side of the wrist or ankle 074, to and passes under 071 back to other section of the clasp and then returns to the Power module 071. This design makes it impossible to remove the Transponder from the wrist with interrupting the power supply, either by unlatching the clasp or by cutting the conductive band 074. The Transponder has a power storage capacitor adequate to send a final transmission when power is disconnected. A final transmission of this nature has an added bit indicating the removal of power. This data bit will remain attached to transmissions until reset, to identify removal and perhaps reconnection to another person, or simply tossed aside to sabotage tracking and monitoring functions. The key to the continuity concept is demonstrated in the Clasp Detail 075. A 4-pin plug connects to a matching 4-pin socket enabling the power wiring to cross from one to the other and return, a process that occurs both for the connection between 070 and 073, as well between 071 and 073.

Diagram 20 shows a system installed in a home, monitoring it for a broad range of characteristics. A single Reader 076 placed in a central location and can receive and decode transmissions from any Transponder attached to any combination of sensors located on the property inside or outside the home. A fireplace in the living room, 077 is monitored by Transponder 078, which has temperature and smoke sensors. It may also monitor the concentration of combustion products and toxicity vapors. Similar Transponders 079 and 081 are shown placed by fireplaces 080 and 082. In the event these fireplaces are gas operated, the transponders would also monitor for natural gas or propane leaks. The master bedroom Transponder 083 would monitor in a similar manner,

but in this case perhaps sensing for smoldering caused by an improperly discarded cigarette or a poorly placed candle. Not shown could be a Transponder attached to a set of life signs sensors on an elderly or chronically ill patient. Transponder 084 would similarly monitor bathroom conditions but could also monitor for bath or toilet overflows, or electrical problems such as shorts or ground fault over loads. Transponder 085 is located in the dining room and may have an added sensor to monitor a food warmer or might monitor a normally locked china or silver cabinet for security purposes. The kitchen Transponders 086 would likely have a variety of sensors with a separate Transponder by each appliance. With a gas range it would include a sensor for gas leaks while an electrical range would have an overload detector. Other bedroom Transponders 087, 088 and 089 would be customized for the occupant, perhaps detecting for allergens, molds, bacteria or other airborne threats. Transponder 090 is located outside the house perhaps by a barbeque sensing for propane leaks in addition to the temperature and other sensors. Transponders 091 in the garage would sense for the same parameters as other sensors, but might also include a gasoline sensor, workbench electrical shorts and ground fault overloads. Vehicle mounted transponders could monitor tire pressures and battery condition, alerting the owner ahead of time to a potential flat tire or dead battery in the morning. Other transponders can be monitoring movement in each room, opening and closing doors and windows, be connected to thermostats and conventional security and safety devices like fire and smoke alarms, even monitoring such obscure criteria like termite or carpenter ant infestations. Also not shown in the drawing are other Transponders with sensors that can monitor, pool and garden gates, pools and ponds, mailboxes, even the moisture level in the soil for irrigation optimization. Solar heating systems, wind force, earth tremors can be monitored. City water can be monitored for purity and freedom from biological contaminants, and for sudden surges that might indicate a leak or burst pipe when compared with motion sensors that show no one is in the house. Similarly surges in electricity or gas usage could detect shorts or gas leaks, again the benefit of comparison with temperature rise, detection of combustion products or the detection of a high natural gas or propane concentration in the air.

Drawing 21 shows a high Yagi Antenna specification for achieving a 1500 read range

Drawing 22 shows a building application with a centrally located Reader 092 that locates transponders 093 and 094 that move, or may move, around the building, by locating fixed, coded, location pollers by each doorway 096, periodically along corridors 097 and at stairwells. As the moving Transponder passes within the very limited range of this directional poller, it receives and decodes the polling signal, adding that code to its own. The same Reader can receivers other Transponders monitor various building conditions such as doors open or closed, lights on and off or the status of other items 095.

Drawing 23 shows a building outfitted with pollers 102 that can be used to locate people, Laptop computers and other tagged assets as the move, are relocated or removed from rooms or the building, or even from one floor of the building to another. Pollable Transponders 101 will pickup, extract the Pollers' location identification code and add it to its own identification code which it then transmits to the Reader 103. The Poller might also include an additional bit to notify the control center of the transmission, status of

each door (open or closed) or even whether the light is on in the room. The key here is the very short range and directionality of the pollers, that are simply another version of a Transponder, with a lower power transmitter and a directional antenna where required. The Transponders have been designed to be able to switch frequencies by simply a change of Transmitter hybrid component or by replacing it by a frequency programmable transmitter.

Drawing 24 shows a similar application to Drawing 23 except in this case the doorway modules are sensing Transponders, identifying open and closed doors, lights on or off, and other conditions, and transmitting the data to the Reader 105 periodically or immediately a change in status occurs. In this the Transponder 106, which can also be read by the Reader, would likely be a used just for identification purposes and perhaps to provide its own sensor information. It should be noted throughout these applications that the read range of the Readers can be programmed to limit the field being monitored. As will be seen later there is 16-bit remotely programmable attenuator in the Reader before the RF receiver circuit that is used to define the read range.

Drawing 25 shows a Responder version of the Transponder. In this application the components are only included in circuit 098 if the Poller is intended to operate only when it recognizes that a Transponder with a short pulse beacon is within range, it which case it will transmit its information, and where applicable its instructions, before shutting down. For Pollers without this circuit populated they are programmed to transmit intermittently. As a Poller the temperature monitoring circuit 099 is normally not populated but in some applications temperature, or temperature history, may be part of the information to be relayed by the Transponder back to the Reader, since the responder has only a very short range, or may be operating on a different frequency that the Reader. An example of this application might be a Responder that is monitoring an environment but there is no requirement to send this information directly to the Reader, or its not practical to do so, or the information is only important when a short pulse beacon Transponder is in the vicinity. The Responder transmitter hybrid 100 can in some circumstances have the same frequency as the Transponder, but in the majority of applications it would operate at a different frequency list in Drawing 10 or it may operate at 13.56MHz or a lower frequency.

Drawing 26 shows an example of a control center display such as might be used in the application show in Drawing 24. In this case each sensing transponder is designed to sense five conditions (this is an example of a one bit sensor response). A total of twenty Transponders are each monitoring five conditions such as doors, drawers, switches and other conditions open or closed, off or on, etc. The display identifies the Group Code, there may be more than one company using the building in which case the display might be password protected to show only a particular Group Code. The next column identifies the unique Transponder code, followed by the status of each of the five conditions being monitored. A red entry indicates a change from the previous reported status and a bold line indicates that the Transponder is not reporting and shows the last received status. The display also provides other pertinent information. Instead of the template a building plan could be used similar to Drawing 24 and the door, drawer, lights, etc. could be shown

actually open or closed, on or off, and a change highlighted in red and an un-read situation in another color. This could also we used where other Transponders are being monitored (such as location tags) in which case it could its location and movement around the building. Other conditions such as temperature, natural gas concentrations and the like can also be monitored if the appropriate transponder is installed.

Drawing 27 shows a system block diagram of a pollable Transponder 107, a Reader 108 and the polling transmitter 110. The poller can either instruct the Transponder to send its data immediately or provide other instructions. As in other system configurations the Reader 102 decodes and further analyzes the data before periodically sending the information on to a control center 103 PC or PDA. If an anomaly is confirmed it will send data immediately to whichever prescribed phone number or LAN address indicated for that particular event.

Drawing 28 shows a system block diagram of a Transponder 101 and Reader 102 with two-way communication. In this case the Reader can provide the Transponder with polling or other instructions instead of a separate polling transmitter. The benefit of this type of system is that it provides the Reader with the ability to interrogate the Transponder when it detects a problem but needs to modify the collection of further data. It also leads to the ability of introducing sensor modules 106 that also provide control functions when called for. As in other system configurations the Reader 102 decodes and further analyzes the data before periodically sending the information on to a control center 103 PC or PDA. If an anomaly is confirmed it will send data immediately to whichever prescribed phone number or LAN address indicated for that particular event. The transceiver feature also provides the ability for the control center that always has two-way communication with the Reader, to send instruction to the Transponder via the Reader that then serves as a two-way relay or repeater between the person receiving the data and the monitoring (and control) Transponder. The Transponder's RF section in this has the normal RF hybrid transmitter replaced by a Transceiver hybrid 105 and similarly for the Reader's RF receiver section 104.

Drawing 29 is a view of a sensing transponder. In this application the power module 105 and sensor module 106 each plug directly into the main module 107. The attachment cleats 108 can still be used for connection to the host.

Drawing 30 is an exploded view of the flat sensing transponder again showing power module housing 109, power module battery insert 110, housing for the main module 111, main module electronics 112, sensor electronics 113 and the sensor module housing 114. Other features shown are the sensor module multi-pin plug 115, matching main module multi-pin socket 116 and socket 117 (for power module attachment) and power module plug 118.

Drawing 31 is view of the basic transponder consisting of the power module 119 plugged into the main module 120. In this case a snap cap 121 is used to seal the unused sensor module socket. There are several versions of this cap, one being a snap on cap used only for sealing purposes, and the others are using for setting certain transponder operating

conditions. For example, the main module's hybrid transmitter can be operated in either an OOK modulation mode or ASK modulation mode. The appropriate cap is attached to achieve the selected modulation mode. It can be removed and replaced with the alternate cap version if the modulation method needs to be changed. All of the sensor modules and other special custom attachments have the same modulation setting option.

Drawing 32 is another exploded view of the basic transponder again showing power module housing 122, power module battery insert 123, housing for the main module 124, main module electronics 125 and the selected end cap 126. Other features shown are the end cap multi-pin plug 127, matching main module multi-pin socket 128 and socket 129 (for power module attachment) and power module plug 130.

Drawing 33 shows the use of a Transceiver Hybrid Circuit in place of the Transponders Transmitter and the Reader's Receiver. The drawing shows how the 16-bit programmable attenuator 200 can be inserted between the antenna and the Saw Filter (and before the inductors RFIO and ESD choke) to provide a field limiting function that prevents Transponder out of the desired range from being received, and how the 16-bit Signal Strength Comparator circuit 2001 can be used by tapping off the signal prior to the Peak Detector circuit.

Drawing 34 is an exploded view of the power module showing the housing 135, attachment cleats 136, and battery insert 137 and plug 138. The drawing also shows the sealing bullhead 139 that is present on all module inserts.

Drawing 35 shows close up view of the main module 140 containing the micro-controller, RF transmitter, polling circuit, temperature sensor, battery condition monitor, transmit inhibit switch and poll response LED. It shows the sensor interface sockets 141 and 142, cleats 143, and the sealing tongue 144.

Drawing 36 is an exploded close up view of the main module showing its case 145, attachment cleats 146, electronics PCB 147, socket 148 and 149, and the sealing bulkheads 150.

Drawing 37 shows close up view of the sensor module 151 showing the plug 152 that interfaces with the main module, cleats 153, and the sealing tongue 154.

Drawing 38 shows an exploded close up view of the sensor module showing the case 155, electronics PCB 156, plug 157 that interfaces with the main module and the sealing bulkhead 158, cleats 159, and the sealing tongue 165.

Drawing 39 shows the basic transponder (power module and main module) and a ribbon cable 166 plugged into the sensor interface socket 167. This cable serves a variety of purposes that include programming the micro-controller, testing the main module functionality including setting the modulation method to either OOK or ASK, or to interface sensors. In an actual installation where the transponder is connected to external sensors, the plug would be built into an end cap to provide a sealed assembly.

Drawing 40 shows the power module 168 connected to the main module 169, showing the cable and plug assembly 170 before insertion into the sensor connection socket 171.

Drawing 41 shows the main module 172 in a further test configuration where the power is also supplied through a plug in cable 173 allowing a complete in process test of the main at various voltage levels and to measure current drain in various modes and conditions of operation, and with various sensor loads. The main module alone, or with any form of sensor connection, can also be powered from an external source used this power cable connector but the plug would then be built into an end cap to provide a sealed assembly.

Drawing 42 shows the main module with the two unplugged cable connectors 174 and 175.

Drawing 43 is an exploded view of a sensing transponder.

Drawing 44 is a block diagram of the basic LIMIS Reader. The RF Section consists of an RF Receiver 177 with connectors for one or two (for diversity) antenna 176, an antenna-receiver impedance matching circuit and an OOK/ASK receiver (within 177). There are two identical RF sections per circuit as shown in this drawing. An optional 16-bit programmable attenuator stage(s) 181 may be included between the antenna(s) and the Receiver. The attenuator stage is controlled by the Microprocessor 186 directly, or on instructions to the Reader from the control center. This provides the ability to limit the receiving range of the Reader to the area of interest and reduces noise or collisions from other Transponders or Tags that are outside the area of interest.

The Analog Section has a gain circuit 178 that consists of a differential amplifier and a summing amplifier. The differential amplifier provides gain and offset adjustment while the summing amplifier adds the two (1 per receiver) signals together. The Analog Section also has a filter circuit 179 consisting of an active filter reduce signal noise. The Digital Section has a level detector 180 consisting of a 16 level voltage divider, 16 comparators and an upper and lower level voltage adjustment. The voltage divider provides 16 equally spaced voltage reference levels for the 16 comparators. Each comparator detects if the received signal is high or lower than its voltage reference. The upper and lower voltage references are adjusted using a potentiometer. This Level Detector serves to provide a calibrated 16 bit Signal Strength functions with the range sensitivity being controlled by the 32-bit processor 186. Where a 16-bit Attenuator Read-range adjustment feature is used, the output of the 16-bit Signal Strength function must be linked to the attenuator setting. This could be used to provide a 256-bit Signal Strength function although this precision would rarely be used because of the many potential attenuating factors associated with radio signals. One application it can be used for, where the attenuating factors are specific to the nature of the environment and location, is to provide a very accurate analysis of these attenuating factors which could be determined prior to an installation and then programmed into the Reader or the central control computer, and used to refine the Signal Strength readings when using the system for locating purposes.

The CPLD functions consist of a 16 level to 4-bit converter 182 that de-bounces the incoming bits and converts the data to a 4 bit binary code. A Digital Squelch function 182 is used to set a minimum signal value. Any signals below the digital squelch level are ignored. The Digital Filter 184 performs a weighted average on the signal. Each sample is weighted based on the age of the sample, and the older the sample the less weight a sample has in the average. This provides a smoother signal and reduces noise. A Slope Detector 185 looks for slope changes in the signal. There are currently 3 types of slopes detected (up, down & level). Any change in slope type is detected in the Event Rate Detector 187 and a pulse is generated. An 18-bit counter is used to keep a rolling count of the 4MHz clock 188 in a binary format. A Time Stamp Latch 190 latches whenever a pulse is latched from the 18-bit counter 189 whenever a pulse is received from the slope detector. All rollover events are also latched to aid in tracking event timing. All data captured in the time stamp latch 190 is also loaded into a 4K x 18 bit FIFO (First In First Out) 191 Memory device. The FIFO is used to store time stamps until the microprocessor is ready to read them. Event Rate Detector is used when time stamps occur at a rate that is faster than the known signal rate, it makes an automatic adjustment to the digital squelch circuit which effectively eliminates fast noise signals. The microprocessor reads data from the FIFO and analyzes the time stamps to decode data from the transmitter. The microprocessor also controls the potentiometers that adjust the upper and lower threshold levels. The microprocessor also sets the level in the digital squelch circuit, and acts as the interface to the system computer.

Drawings 45 to 54 show the PC-104 LITMIS Reader Board detailed circuit schematic and Drawing 55 to 62 show the detailed LITMIS PCMCIA Reader circuit schematic for the external antenna card with the range selection circuitry (drawing 56). Drawings 63 to 72 show the PCMCIA Reader board layout for the external antenna card, and Drawing 73 the layout with the internal Splatch component antenna. Drawing 74 shows the nature of the Splatch Planar Antenna this is used in the LITMIS PCMCIA Reader. Another advantage of using a PCMCIA Reader is that when used with a dual slot PCMCIA expansion Pak (such as iPAQ's), the second slot can be used with 802.11 Modem for communication with the control center.

Drawing 75shows a view of the assembled, fixed LITMIS PC-104 Reader 50 with mounting flange 51. Also shown is the dual PCMCIA slot 52, serial connector 53, power connector 54 and LAN connector 55. Also shown are ten coaxial connectors, one for a WLAN antenna 56, one for a GPS antenna 57, and eight connectors 58 providing coax cable connections to the maximum number of four, dual (orthogonal) antennae.

Drawing 76shows an exploded view of the fixed LITMIS PC-104 Reader showing the case 60, the cover 59 and mounting flanges 51, the dual PCMCIA slot 52, serial connector 53, power connector 54 and LAN connector 55. Also coax sockets 56, 57, and 58. The four PC-104 boards shown are PCMCIA two-slot Module 61 that can be used for GPS or 802.11 cards or even one of two LITMIS PCMCIA Readers (such as Aaeon PCM-3115B), CPU Module 62 (such as Aaeon PCM-4335 or 3336), Ethernet Module 63 (such as Aaeon PCM-3660) and the LITMIS Reader 64. Other PC-104 options include a Vehicle Power Supply Module for Wheel and Axel Monitoring Systems, fork lift, golf

cart or similar applications, 48-channel DIO Module such as Aaeon PCM-33724), Isolated RS232/422/485 Module (such as Aaeon PCM-3610), or a Cell Phone/Internet Communications Board (including boards such as Ubicom's PhantomServer). All these are either alternates to the Ethernet Module or the stack can be expanded to include multiple options.

Drawing 77 shows a use of a pollable Transponder (that doesn't transmit unless polled) and a repetitively transmitting Poller, as a scoring method in a wide range of sporting events. A short-range Poller with a directional antenna is located on either end of the scoring line with the transmissions directed across the track so as to cover the full width of the scoring line and assure that a transponder crossing the line will receive the polling signal. The instant the transponder receives the polling signal it transmits its code to the Reader located nearby, thereby notifying the Reader that the Transponder has just crossed the scoring line, and time stamping that reception.

Diagram 78 shows a use of a pollable Transponder (that doesn't transmit unless polled) and a repetitively transmitting of a coded Poller as a scoring device in sporting events where there are a number of scoring lines periodically spaced over a wide area. A short-range coded Poller with a directional antenna is located on either end of the scoring line with the transmissions directed across the track so as to cover the full width of the scoring line and assure that a transponder crossing the line will receive the polling signal. The instant the Transponder receives the coded polling signal it transmits its code along with the Poller's code to the Reader located anywhere within a 1500 foot radius, thereby notifying the Reader that the Transponder has just crossed a specific scoring line, and time stamping that reception.

A further version of this scoring method involves replacing the coded Poller with a coded Responder, a polling device that only transmits its code when it receives a prompt from a Transponder in range. In this method the Transponder, in addition to the functions described previously, also sends out a very narrow low power beacon pulse every tenth of a second to every second, depending on race speeds (walkers, runners, skiers, sleds, horses, vehicles), except when it is sending its polled data to the Reader. The Responder acts as a pollable Poller. In other words a Poller that only transmits a polling signal when it receives a beacon prompt.

Drawing 79 shows a sensor application that provides the ability to provide remote surveillance of stored radioactive items and to detect radiation in monitored environments. The application has the ability to handle nonproliferation monitoring, spent fuel safeguards and long term monitoring of stored radioactive wastes by using the features of LITMIS that sample, average, establish parameter normals and then continuously compare readings every few seconds against absolute and rate of change limits. Data transmissions to the Reader can be hourly or daily except when anomalies are detected in which case transmissions can be repetitive or continuous depending on the seriousness of the condition.

Drawing 80 shows a LITMIS PCMCIA Reader card 202 plugged into an iPAQ PDA Expansion Pak. In this case the PCMCIA Reader has an internal stub or Spatch antenna. Although not shown where a dual PCMCIA slot expansion Pak is used, an 802.11 modem card can also be inserted to provide radio communication to the central monitoring computer. In this configuration the LIMIS PCMCIA Reader must be the Splatch version and the card must have a reverse connection into the slot compared to the 802.11 Modem. All Splatch versions of the PCMCIA Reader are configured that way, thus avoiding communication problems because of the close proximity of the two PCMCIA cards. This orientation problem does not occur when PCMCIA Readers have an external antenna. Another configuration option is to use both slots for LITMIS Reader cards with external antennae that are designed to be extended into to perpendicular directions to provide a diversity feature if the application calls for it.

Drawing 81 shows the LITMIS system components concepts described in this document.

Drawings 82, 83 and 84 show an alternative encoding method that can also be used with the LITMIS hardware where it use is intended for much larger numbers of Transponders for a large number of potential customers.

Two additional sets of commercial documents (each five pages) are also attached that describe a ground moisture sensor that can be used with LITMIS product, and an Event Detector Interface that can be used in place of the Sensor Module. In this case the sensor Module would have a mechanical design similar to the main module allowing for either an end cap when sensors are included in the Event Detector Module or a Ribbon Cable Plug-in when Event Sensors are remote to the LITMIS Transponder itself.

APPLICATIONS

The breadth of systems applications that can be covered by the modular, re-programmable, multi-sensor options of the transponder and the ability to deliver the received information to remote locations, particularly involving cell phone and internet connection is the innovative aspect of the invention. In many cases the Transponder itself, or the Reader or central computer could allow monitoring of selected sensed parameter for a period of time while it "learns" what the typical variation of that parameter is and establishes normal maximum and minimum values for it. After that period of time the system would only notify the owner (or designated overseer) when a value goes outside that acceptable range.

For example: Security Related Applications

A multi-application installation is remote security and safety monitoring of containers, storage areas, warehouses, water supplies, utility plants, industrial and commercial facilities, and transportation centers. Key features include:

Adaptable to any combination of sensors, transducers or detectors with analog or digital outputs. Small, multi-application, field re-programmable wireless data monitoring of

people and environments. Continuous sampling to identify anomalous absolute and rate of change conditions. Ability to notify programmed locations of emergencies and provide real-time data. Provision for adding multiple sensors or sites for expanded monitoring or enhanced situation analysis. Provides multiple level decisions from the Transponder to the Control Center personnel. Anomalous parametric data can be selectively presented as warnings, alerts or alarms. All Internationally approved wireless bands, very low power, narrow pulse, periodic transmission

Examples of monitored parameters:

1. Anomalous Radiation (indicating the presence of Radioactive Materials.
2. Explosives Emissions or detection of selected Chemical or Biological Agents.
3. Electricity Usage (abnormality indicating lost of power, a short or unusual usage)
4. Water Quality (identifying the presence of poisons or contaminants)
5. Natural Gas Usage (abnormality indicating a lost of service or a leak)
6. Fluid Level in Fuel Oil or Gas storage tanks (indicates a leak or refueling need)
7. Temperature (abnormality indicating a lost of heat or air conditioning, or a fire
8. Humidity (abnormality indicating a medically required humidification system malfunction)
9. Allergens (medical risk from bacteria or other air born particulates or contaminants)
10. Light Level (abnormality indicating lights left on or a possible intrusion)
11. Noise Level (abnormality indicating dog barking, something breaking or phone ringing)
12. Circuit Breakers (indicating tripped breaker, perhaps an alarm failure)
13. Weight or Load (abnormality indicating overload or over stressed condition)
14. Identifying Movement (sensing of invaded premises or unauthorized presence)
15. Identifying Open Doors or Windows or other Security Breeches (monitoring locks/switches)
16. Locating or tracking Items, People, Vehicles and Objects

The system has the ability to analyze simultaneous input from multiple sensors thus providing the means, as programmed by user, to better understand the nature of anomalous data and the rate at which it is changing in real time, and to be able to do this at a remote location.

Similar sets of applications achievable with a single installation include commercial offices and workplaces, warehouses and factories, manufacturing plants and power stations, maintenance depots, theme parks, underground mines, military deployments, marshalling yards, airports, docks, shipping containers, vehicles, planes, ships and in fact in any situation where a combination of Location, Identification, Tracking, Monitoring, Interrogation and/or Sensing functions are required and particularly where real time notification of persons remote from the site is necessary. The major feature of this innovation is the ability to accomplish all of the above functions with a single modularized, post-programmable design that can deliver the sensed or interrogated information from anywhere to anywhere instantly. The firmware in transponders can be re-programmed in the field and Reader software can be re-programmed through a wide

choice of wired or wireless options. If it can be sensed, it can be remotely monitored without wired connections.

Another application: Residential Monitoring

1. Monitoring Electricity Usage (abnormality indicating lost of power or a short)
2. Monitoring Natural Gas Usage (abnormality indicating a lost of service or a leak)
3. Monitoring Water Usage (abnormality indicating a lost of supply or a leak)
4. Monitoring Fluid Level in Fuel Oil or Gas storage tanks (indicates order needed)
5. Monitoring Temperature (abnormality indicating a lost of heat or air conditioning, or a fire or appliance/oven/hot plate left on)
6. Monitoring Humidity (abnormality indicating a medically required humidification system malfunction)
7. Monitoring Allergens (abnormality indicating a potential medical risk from excess pollen, dust, bacteria or other air born particulates or contaminants)
8. Monitoring Light Level (abnormality indicating lights left on or the sun is up)
9. Monitoring Noise Level (abnormality indicating dog barking, something breaking or phone ringing)
10. Monitoring Pool or Pond Water Level (abnormality indicating overflow or water needed)
11. Monitoring Pool Water Condition (abnormality indicating pH, Chlorine, hardness and contaminant problem)
12. Monitoring Pool or Pond Water Agitation (abnormality indicating something or someone fell or jumped into the pool, or there is a strong wind or an earthquake)
13. Monitoring Fish Pond Water Quality (abnormality indicating lack of Oxygen, presence of poisons or other contaminants)
14. Monitoring Soil Moisture Level (abnormality indicating failure of irrigation to expensive newly planted trees or broken line causing flooding)
15. Monitoring Lawn Moisture Level (abnormality indicating failure of irrigation or jammed sprinkler head)
16. Monitoring Rainfall/Snowfall and rate of precipitation (abnormality indicating a need for taking some action – perhaps turning off the sprinkler)
17. Monitoring Wind Speed/Gusts (abnormality indicating a need for taking some action – take down awnings and implement damage control)
18. Monitoring Density of Wooden Rafters and Studs (abnormality indicating possible infestation of Termites or Wood eating beetles)
19. Monitoring Freezer/Refrigerator Temperature (abnormality indicating failure and risk to food and perishables)
20. Monitoring Vehicle Tire Pressure from inside the house (abnormality indicating overnight air leak)
21. Monitoring Vehicle Fluid Levels from inside the house (abnormality indicating a need for coolant, fuel, oil or brake fluid before driving off)
22. Monitoring Solar Heating/Power Generation (abnormality indicating a system failure requiring attention)

23. Monitoring Elderly or Chronically Ill Patients (lack of movement or a fall indicating a need for checking on them, even monitoring blood sugar, pulse, etc.)
24. Monitoring Mail Box Opening (indicating delivery of mail, illegal removal of mail and mail box destruction)
25. Monitoring Circuit Breakers (indicating tripped breaker, perhaps an alarm failure)
26. Monitoring Weight or Load (abnormality indicating overload or over stressed condition)
27. Identifying Movement (sensing of invaded premises or unauthorized presence)
28. Identifying Open Doors or Windows (sensing a young child getting out, teens arriving home at night, a door or window left (or blown) open, garage door open)
29. Identifying Security Breeches (sensing a safe or security vault being opened, or a secure area being entered, or an valuable item being removed)
30. Locating Items, People or Pets (integrated into a single monitoring system)

Similar sets of applications achievable with a single installation include commercial offices and workplaces, warehouses and factories, manufacturing plants and power stations, maintenance depots, theme parks, underground mines, military deployments, marshalling yards, airports, docks, vehicles, planes, ships and in fact in any situation where a combination of Location, Identification, Tracking, Monitoring, Interrogation and Sensing functions are required and particularly where real time notification of persons remote from the site is required. The major feature of this innovation is the ability to accomplish all of the above functions with a single modularized, post-programmable design that can deliver that information from anywhere to anywhere instantly. The firmware in transponders can be re-programmed in the field and software in the Readers can be re-programmed through a wide choice of wired or wireless options.

POLLED TRANSPONDER SYSTEM AND METHOD FOR IDENTIFYING STATUS AND LOCATION OF HOSPITAL ASSETS, PERSONNEL AND PATIENTS IN MULTI-STORY BUILDINGS

John J. Coulthard

Abstract

The system consists of three low power wireless components, Transponders, Pollers and Readers. The Transponders are battery operated with a life of five to ten years, a micro-controller module with a polling receiver, and several situation sensors. The Poller is a short-range transmitter that can wake up a nearby or passing Transponder and provide coded transmissions to an accepting Transponder that cause it to revise its programmed instructions and transmit its identity, status and location information to the Reader in the manner indicated by the Poller. In these applications there are a number of options depending on the intended modification or addition to the information normally being transmitted by the Transponder. A Transponder receiving transmissions from more than one Poller is able to react to instructions from a selected Poller or in some applications may combine instructions from two or more Pollers. One particular application locates and tracks a Transponder by relying on transmissions that are only necessary when a Transponder moves to a new location, specifically identified by the Transponder. A unique sequence of transmissions may be initiated after which no further transmission is required until the Transponder is moved and hence the location information needs to be updated. This eliminates the problems with conventional RFID technology when Transponders are placed in steel cabinets or reception of beacon transmissions is temporarily interrupted.

The Readers consist of receivers with signal processors that can be integrated into PDAs or PCs, PCMCIA Reader cards that can be used with any computer having a PCMCIA slot, and Readers with an embedded computer that have communication links such as LAN, WLAN, Cell Phone, Internet and radio. All of the processor based system components are customer programmable and can be interchanged between applications in the field. A single Reader can be programmed to receive and decode any combination of Transponder configurations that may be within its reception range at any time.

BACKGROUND OF INVENTION

The present invention relates to apparatus and methods that can be used in a wide variety of applications such as remotely locating, identifying and tracking people, items, vehicles or other objects particular the time they pass a certain location, and they can be configured to monitor and adapt to a variety of sensed conditions. This enables the product to be configured for use in the location and status of people, equipment and other items in multistory buildings and underground facilities and other locations. More generally the invention relates to apparatus and methods that utilize condition indicators, coded polling transmitters, micro-controllers that can interpret data and instructions from

remote sources, and can transmit this information to readers that receive, decode and present the information for review, analysis and the determination of appropriate action. Furthermore with the ability of the reader to send information immediately by wired or wireless communication, any information can be delivered in real time to anywhere in the world, all with a single reader or with an arrayed set of identical readers.

Many systems exist that provide some specific function or functions described above but none have achieved the degree of standardization or universal applicability that enables a system to be customized to meet certain application requirements without the need to develop new and untried hardware variations or that can be integrated into a common information collection system. This can only be achieved by a concept that addresses the nature of mechanical versatility, functionally modularity, real time programmability and environmental adaptability. A hardware system and method that is essentially application independent but can be constrained to specific applications, to the extent necessary, by solution providers who incorporate appropriate custom firmware and software.

An important aspect of the invention is the modularized nature of the Transponder and its mechanical and functional versatility. It consists of three primary elements, two of which are common to all applications and environments described previously. They are the power module and the main module that contains a micro-controller and the RF communication circuitry. These two modules are sealed and plug together to achieve an electrical link. The main module has connectors on both ends. One end is used both for programming and testing using a ribbon connector. In use it is the end to which the power module it attached. The connector at the other end is used for testing and selecting certain functional options such as transmitter modulation mode, pulse widths and frequency, and is also used to plug in the third module or connector. This third module can have a variety of features from simply a sealed cap that selects the transmission characteristics and protects the connector when used only for beacon applications, to a choice of active status sensing connections that provide information regarding its host such power off or on, a door open or closed, a switch up or down, temperature hot or cold, location in the light or dark, item moving or stationary, etc

Another key feature of the system is the means by which transponders although configured for real time inventory tracking can be customized for a wide variety of sensing and conditions applications that can all be read together using the same Receiver. The method described here also requires that the content of communication from the Transponder to the Reader contain a variable word length and a variable number of words in each transmission, depending on its circumstances and instructions from Pollers . This is possible because the transponder for all these applications is the same except for its transmission data content and the special purpose module. However, the data encoding format is the same for all transponders except for the word length, number of words in a transmission and the nature of the encoded information, although these variables are limited to a predetermined set of options, the option being identified at the beginning of the transmission. The Universal Coding Format used in the Transponder's transmission contains information needed by the decoder to recognize the data as coming from a particular transponder configuration. The Universal Coding Format provides information

regarding the type of the transmission encoding scheme (Transmission Type Code), an application specific group code, a unique transponder code, a polling code, and a variety of event status or sensor data bytes, which can each have a different number of bits, or even none at all. The nature of the encoded information is programmed into the Reader software as a look-up table and identified through the transponder's individual code.

The polling scheme can have a variety of features depending on the nature of the application. If the Transponder is stationary, the polling signal may either be have been received from a hand held PDA (serving both as a Poller and a Reader) in order to have it send its current status and location information immediately instead of at its normal periodic rate, or the polling signal will have been received from a Poller located in the vicinity. Typically the latter signal will be ignored when the transponder is stationary. It is important that the polling transmitter (whether part of a PDA or a site-located Poller) should have only a limited range so as to address only those Transponders within a few feet of the Poller.

The transmission scheme is set up to have a maximum bit count for each byte, which may be different for each byte, and a maximum byte count for each word, which may be different for each byte. In addition there may be a different number of words in each Transponder's transmission. There are only a specific number of different transmission schemes that are defined by The Transmission Type Code, which is programmed into the Reader's memory as a look up table.

TRANSPONDER

Stationary Operation

The Transponder wakes up every five seconds (or as otherwise programmed or instructed by a Poller) and checks for motion, polling reception and battery voltage change. If it has nothing significant to report it returns to the sleep mode. Once an hour (or as otherwise programmed or instructed by a Poller), the Transponder will re-transmit the last message sent (with a No-Change Bit indicating it as timed transmission not an event triggered transmission).

When a Transponder wakes up and it detects a rate of change of battery voltage or a limit failure (as defined by its programmed look-up table) not previously reported, it transmits the last message sent but with the new data (and with a Data Change Bit indicating an event triggered transmission).

If a Transponder detects a PDA polling message while stationary, it transmits its identity (TI) three times and returns to its sleep mode. The polling signal from a PDA has an identity code common to PDAs to distinguish it from Location Pollers. If a Transponder detects a location-polling message while stationary, it may be programmed to ignore it.

It should be noted that the person handling the PDA controls the polling message and they maintain the transmission long enough for the Transponder to wake up and receive it

(over 5 seconds in this example). A Location Poller transmits a very short message every few seconds which is directed at moving Transponders that stay awake as long as they continue to move.

If a Transponder, on waking up, detects motion for the first time, it transmits its identity (TI) and other programmed information (and/or Poller instructed information), including a Start Motion Bit (SMB), and remains awake as long as the motion continues in order to be aware of a stopping of motion, unless the motion sensor/microprocessor interface enables a sleeping processor to be awakened by a the stopping of motion.

In-Motion Operation

If a Transponder, while in motion, detects a polling transmission, it checks the Poller's Identity (PI) for authenticity and then checks against a Current Polling List to see if it is the first time it has received this poll since it started moving. If the PI is authenticated but it is not on the current Polling list, the Transponder appends Poller's name to its data stream and transmits this information according to its programmed instructions or as modified by the Poller's transmitted instructions with a First Time Polled (FTP) bit for that Poller, and enters the Poller's ID into the list of current Pollers.

As long as the Transponder continues to receive a specific Poller's signal (in other words it is found on the Current Polling List) the Transponder will typically not repeat its previous transmission.

The Transponder will check every two seconds (or as otherwise programmed or instructed) to ascertain if a Current Polling List Poller's transmission is still being received. When it first detects, for three consecutive sequences (or as otherwise programmed or instructed), that it has not received that Poller's signal, it re-transmits the last message with a Last Time Polled (LTP1) bit for that Poller, and removes that Poller ID from the Current Polling List.

If a second Poller's transmission is received and authenticated while there is already another (active) Poller's name on the Current Polling List, this name is also appended to the Transponder's data stream and it transmits this information according to its programmed instructions or as modified by an earlier (still current) Poller's transmitted instructions, or as superceded by the latest Poller's instructions, with a First Time Polled bit for that Poller (FTP2), and enters the Poller's ID into the list of Current Pollers.

If a third Poller's authenticated transmission is received the Transponder will drop the first active Poller from the Current Polling List, replace it with the current second Poller's ID and add the third Poller as though it was a second Poller (as indicated in the previous paragraph), except in product specifically designed to have a Current Polling List of more than two Poller IDs.

If the Transponder continues to be in motion without any ID on the Current Pollers' List its status returns to that described in the first paragraph of this In-Motion Operation section.

If at any time during which Poller signals are being received, the Transponder's motion stops, the last signal transmitted by the Transponder is repeated except with a Stopped Motion Bit and the Transponder status returns to that described in the first paragraph of this Stationary Operation section.

Other Functions

The Transponder has the ability to receive and analyze sensed information both digital and analog. In its simplest form it can receive a one bit state indicator such as off-on, open-closed, up-down, etc. In this application the transponder can be used to monitor if the item to which the Transponder is attached is in use or not, either by sensing a power-on condition, using a thermal or mechanical sensor or by manual instruction, or a combination of these. This is indicated by an Equipment Status Bit (ESB) "0" for in use, "1" for available. Further status bits can be used to indicate a just completed calibration or an out-of-service condition. Other information can be provided to the Transponder to be relayed to the Reader either in the form of a state indication or as analog data. Examples of this are the amount of oxygen or other fluid remaining in a cylinder attached to a wheel chair or item of equipment, that the process of sterilization has been implemented between its being used for different patients, that tubes or needles have been replaced between being used for different patients or other consumable items have been replenished. The system can also be used to match equipment with a patient by having patient Pollers (or Transponders with the Poller being on the equipment), when the equipment is in use (and stationary) adjacent to the patient the transponder can relay this information to the reader and then presented to the monitor, which software can be used to check treatment assignment and schedule to determine if a match has been achieved.

Fixed Transponders may be used to provide monitoring information for fixed equipment to provide information on operational status as well as service, calibration and other factors. They can also be used to monitor room environments and other areas for correct temperature, humidity, sound levels, light levels and warn for airborne contaminants such as biological and chemical agents, allergens and radioactive contamination.

POLLERS

Pollers can be programmed to send out a transmission than includes the ID of a specific Transponder (or Transponders) and Transponders can be programmed to respond only if their ID is contained in a received transmission or only respond to certain preprogrammed instructions or only to respond to certain of the instructions transmitted to it by the Poller. Furthermore, some Pollers may provide a security benefit by alerting authorities to the presence of a certain item in a limited access location or unauthorized removal from a location or from the building. An example of this could be the removal of life support equipment from an area in which it is required to remain. Another example is

the operation of equipment in an unauthorized location or location intended only for storage of the equipment when not in use. Multiple equipments in the same location may also be an undesirable situation that can be flagged with this system. In other situation equipment may be limited to adult use and therefore should not be present in a children's ward, or it should not be used for pregnant women and hence should not be present in a maternity ward, or similar requirements in quarantined areas. Another example is to alert to a danger that may develop if an item is moved into an area or next to another piece of equipment or person, such as oxygen or other flammable gas in the vicinity of an open flame or the risk of a static spark.

READERS

The Reader can be embodied in a fixed format, typically using two receive channels for diversity or for a PDA application a single receive channel either integrated into the PDA using a serial interface or as a PCMCIA card. In the latter case the PCMCIA card may be implemented using a PCB thin film radiator on the card serving as the antenna, or a Splatch commercial networked antenna, or an external stub or whip antenna. All three versions have been build and tested. The external antenna version includes end connectors on the PCMCIA card, an MMCX connector for the antenna a 4-pin connector for programming and a 15 pin connector for testing or use in a serial output mode. The fixed Reader can be implemented in a PCI format for integration into a PC, a PC-104 format for use with an imbedded processor in a PC-104 styled Reader, or a dual PCMCIA slot PC-104 board can be used and the external antenna PCMCIA card simply plugged into one slot. The second slot can either be used for a PCMCIA modem for transmitting information to a control center by RF or to phone jack, or it can be used for a second PCMCIA Receiver card to provide diversity. In the case of high gain antenna(s) requiring low loss cable connections, a bulkhead connector(s) would be provided on the Reader case for that connection and a micro-coax cable(s) would connect from the bulkhead connector(s) to the PCMCIA MMCX connector(s).

The Reader has a 16-bit attenuator ahead of the RF Receiver which with a wide choice of antennae from ¼ wave Helical antennae to high gain Yagi antenna can be used to limit the range of Receivers both at the installation stage as well as by instructions delivered by the two-way wired or wireless Reader communications link.

The Reader is capable of receiving Transponder transmissions from a distance of up to 1500 feet depending on the nature of the receiving antenna. The Reader on receiving a Transponder's transmission then extracts the Transponder's unique code and the polling code, and time stamps the entry. This provides real time information on the identity and status of an item and the time it was at or passed a specific location. One Receiver can cover an area having a radius of 1500 feet and can monitor a large number of items or people without risk of collision errors because the Transponders typically only transmit when they are moving and then only when they first receive a polling transmission and after loosing a polling transmission. The short range of the polling transmitter limits the number of Transponders responding to those within several feet of the timing location,

and even then is limited to the first and last poll reception, although the system is capable of receiving transmissions from several hundred Transponders polled simultaneously.

TRANSPOLLERS (Hermaphrodites that can serve as Transponders or Pollers)

Transponders utilize motion sensors to assist in locating hospital equipment and patients in multistory buildings by relating the start and stop of motion of specific items with the initial capture or ultimate loss of a local polling signal or a combination of local polling signals, thus providing the ability to track equipment and patients on elevators, in shielded or metal walled rooms and outside the building. A tri-axial accelerometer can be used to separate vertical motion in an elevator form horizontal motion along a corridor. This can be combined with the analysis of other sensed parameters such as whether a wheel chair holds a patient or is empty, or a piece of equipment is powered but not operating or powered and operating.

In a Transpoller embodiment the Transponder and Poller are different configurations of the same system component. The Battery Module is the same for both and the Main Module hardware can be interchanged although the firmware is different. The primary difference is the Transponder has a long-range transmitter while the Poller has a very short-range transmitter that can be achieved by a simple component value change biasing the transmitter stage differently and by reducing the length of the antenna. Additionally the Transponder has a polling receiver the Poller does not, but that can be achieved by simply not populating those circuit components when using the main module as a Poller.

The benefit of this concept is that it reduces tooling, manufacturing and parts inventory costs and provides the ability to quickly adjust to applications that have large differences in the ratio of Transponders to Pollers. Since the Transponders and Pollers can be reprogrammed in the field, a Main Module programmed at the factory as a Transponder can be reprogrammed into a Poller in the field. The reprogramming would also include disabling the polling receiver circuit. One other very unique aspect is that Transponders and Pollers can be interchanged to provide greater functional versatility. For example, a Transponder could be located in a fixed location while a Poller could be located on movable piece of equipment or a person. In either case both the Poller and the Transponder could also have, or be connected to, sensors or state indicators. The difference is that the stationary system component relays the information back to the Reader instead of the movable component. One benefit of this when there are many doorways and other location sites but far fewer equipments or people to monitor, is that it reduces the amount of RF transmissions because the beacon component (the Poller) is now only located on the equipment or people instead of every doorway or location site. The Transponder still only transmits when it has a status change to report. Another advantage of this configuration is the relative positions of the Transponders and Readers can be adjusted during installation to provide the best and most reliable long range RF communication. Since the moving component now only has to transmit a very short distance to a transponder in an optimum location that RF communication will not be affected by the building structure or metal installations.

A further benefit of this system concept is that the interchange of Transponders and Pollers can be selectively implemented around the facility depending on which provides the most optimum performance in given area. An MRI room for example would need to have the long range Transponder located at a site known to be able communicate reliably with a Reader, whereas in wards, lobbies, wide corridors, cafeterias and similar areas, the Transponder is more appropriately located on the movable items.

The beginning of the transmission of both Transponders and Pollers contains a preamble that defines the format of the following transmission. This preamble also provides the identification of the transmission as coming from a Transponders and Pollers. Although Transponders and Pollers can be the identical in terms of hardware, a Poller does not have a receiver or it is inhibited when a Transponder is used as a Poller. A Poller will typically have a lower power transmitter or when a Transponder is used as a Poller it will normally have its transmitter powered down. Normally, a Reader is programmed only to accept a Transponder's transmission and it has high gain antennae for that purpose, Transponders have the capability of receiving Poller signals and since they have very short range receive antenna this contributes to short range reception between Pollers and Transponders.

However, Pollers can be located within range of a Reader's high gain antenna and as indicated the typical application would require a Poller to contain a transmission bit showing it is a Poller and that its signal is to be ignored and the Reader is then also programmed to ignore signals received that include such a Poller transmission bit. However, there are circumstances where the Poller's transmission is intended to be delivered to the Reader in which case the identification bit is modified to allow this, and then the Reader is programmed to ignore Poller transmissions except when this modification is present. This application is particularly valuable when a Reader is located close to an area or fixed object that needs to be monitored using a standard installed system in a dual-purpose mode.

Another unique variation of this system is an application involving transmissions between Transponders. Normally a Transponder receiving a nearby signal from another Transponder will identify it as a Transponder transmission and ignore it. However, again for Transponders that intend their signals to be read by certain other Transponders the Transponder identification bit will be modified and the selected receiving Transponder(s) will be programmed to receive these signals.

For fixed Transponders this feature can be used for relaying data around a hospital without requiring Reader participation such as within an MRI facility or other location where the long-range reception of a Reader is not possible. In this mode the Transponders are programmed to act as Repeaters.

In the case of moving Transponders it can be used to monitor the proximity of two Transponders or the lack of such proximity such as between a patient and a piece of equipment, between a mother and her recently delivered baby, a person and their

assigned wheel chair, or a quarantined patient who shouldn't be near another person or in a restricted area.

The monitoring of many other parameters can be handled by the same system such as identifying the delivery and distribution of equipment and items around the hospital from drugs to transplantable organs, or matching blood and X-rays to the correct patient and for the inventorying of hospital capital assets such as computers, printers, shedders, scanners, televisions, phones all of which can be either located or tracked, if the have a transponder and an alert can be displayed whenever these items are removed from their assigned location, or being removed from the building without authorization.

DESCRIPTION OF DRAWINGS

Drawing 01 shows the Transponder main module circuit schematic with the micro-controller part 001 and the transmit hybrid TX5000 part 002. A polling receiver 006 consisting of the tuned circuit L4 and C7, rectifier D2 and load R4. A resistor network 003 provides the means for onboard selection of either OOK or ASK modulation by inserting zero ohm resistors R6 and R9 or R7 and R8 respectively. Alternatively, all four of these resistors can be omitted and off board modulation decision can be made with connectors J1-9 and J1-10, shown by 004. Circuit 005 and other J2 pins provide the ability for on-board programming or subsequent reprogramming. A simple polling receiver 006 consists of the tuned circuit L4 and C7, rectifier D2 and load R4 and a polling reception indicator 007 consists of LED D1 that is also a means of determining battery condition by reading the voltage at the node between R3 and D1 at the micro-controller pin 2 via R6 when the LED is turned on by the polling reception signal. Also an on-board temperature sensor 008 consists of Q1 and R5. The connector J1, 009, provides the connections to the power module or power ribbon cable and also provides the connections for on-board programming and testing. Connector J2, 010 provides connections for Transponder testing, modulation selection and where the application calls for it, connections to the sensor module, sensor ribbon cable or Receiver module for coded signals. Connector 011 provides a connection for an internal flexible whip antenna that wraps around the inside of the main module case or in some applications can protrude through a water tight slit in the case to provide improved range. The micro-controller (PIC16LF876A or equivalent) also has built in temperature sensing and battery condition monitors but when other micro-controllers are used to optimize performance that do not have these features these alternate options are available, or they can be used to provide an alternate input on these parameters.

The remainder of this section will be replaced to describe hospital monitoring drawings

Drawing 02 shows the layout of the topside of the Transponder PCB 012, the Modulation Selector/Sensor Module connector 013, and the Power Module/Reprogramming connector 014. A via, 015 (J3), is the flexible whip antenna connector.

Drawing 03 shows the layout of the bottom side of the Transponder PCB 012 showing the on-board OOK/ASK selection network 016.

Drawing 04 shows the transmission pulse timing when OOK modulation is used. The time slot 017 is 200uS wide and a "0" bit 018 is 40 uS wide pulse, significantly less than 50% of the time slot, while a "1" bit 019 is represented by four consecutive 40 uS wide pulses (one 160uS pulse) that is significantly more than 50% of the time slot. One example of the use of this transmission scheme is a byte than consist of a start bit 160, a couple of sets of data bits 161 and 162, a parity bit 163 and two stop bits 164, all of this making up a word. The word may be transmitted several consecutive times (three in the example) in cases where the Receiver is required to identify a word two or three times before accepting the data.

Drawing 005 shows a diagram of the transmission encoding method. It shows a maximum of 80 time slots or bits, 030. Bit 1, 019, is the start bit and always a "one" followed by a five-bit byte, 020, that defines the Transmission Type, how many bytes make up the transmitted word and how many bits are in each byte. This is followed by a three-bit group code 021. These three "bytes" always make up the first nine bits transmitted. This is followed by the unique transponder code 022 that can be a byte with as many as 16 bits and a Polling code 023 with as many as 5 bits. Following this are five status or data bytes 024, 025, 026, 027, 028, each of which can have as many as eight bits. Following that there is a parity or CRC byte 029 that can have as many as 8 bits followed by two stop bits 031, both "zeros". The drawing shows the full eighty time-slots and the black fill shows the slots where there are transmissions. The white slots show no bits being transmitted and in the actual implementation these slots are eliminated, as shown by 032, 033, 034, 045, 036 and 037 that is why a preceding byte is needed to identify which bytes are included in the transmission and how many bits each has. This word will be transmitted several times with an interval in between that is determined by the word length and the specific nature of the application.

The polling 038 and data 039, 040, 041 bytes can consist of only one bit. In the polling case a "one" bit indicates that the Transponder is transmitting because of a polling instruction, a "zero" indicates that the Transponder transmitted according to its programmed periodicity (not polled). In the case of data bytes a single byte indicates status of a sensed input, zero or one (low or high), indicating that its monitored location is on or off, open or closed, above or below a limit, within a pair of limits or outside, or any other condition that can be represented by a single bit.

A polling byte 042 of more than one bit indicates the Transponder is transmitting because of a coded polling instruction and the byte represents that code. The Transponder can also be programmed without a polling bit at all and this indicates that the Transponder does not have a polling function. For other data bytes that have more than one bit, the byte represents actual data such as temperature, pressure, acceleration and humidity, or characteristics of a magnetic field, radioactivity, water quality, air contaminants or life signs, and information from thermostats, fire, smoke or security alarms. If less than five inputs are being monitored the "empty" bytes are eliminated. The Transmission Type Code includes information on the exact nature of each data byte, specifically what it represents and the bit to parameter magnitude relationship i.e. degrees per bit, psi per bit,

gauss per bit, etc., and the range of that parameter. The byte can also be used to represent a variation from a "par" value or a rate of change.

Drawing 06 describes a Transponder Firmware Proposal for a specific Application.

Drawing 07 describes a set of Transponder Transmission Periodicity Decision Tables that show a Sensor Sampling Plan and Transmission Periodicity options that might apply to a Truck Wheel Monitoring application.

Drawing 08 describes a set of Transponder Transmission Periodicity Decision Tables that show a Sensor Sampling Plan and Transmission Periodicity options that might apply to Home and Building applications.

Drawing 09 shows a typical Transponder Firmware Flow Chart for a nominal application.

Drawing 10 illustrates the various Transponder configuration options such as Frequency, Modulation mode, Polling and Firmware options.

Drawings 11 and 12 show the means by which the test, programming and external sensor cables, and any plug in sensor or special purpose module, include connections that select whether the Transponder transmits an OOK modulated signal or an ASK modulated signal, further adding to the versatility of the LITMIS product that allows field programming and field configuration, in order to optimize the system's performance for each application. In drawing 27 the transmitter hybrid TX5000 01 can be connected either to operate in an OOK modulation mode or an ASK modulation mode depending on whether the transmit enable connection from the micro-controller is connected to the TX5000 pin 17 or pin 18 (the unconnected pin is grounded). To achieve this for OOK modulation the connection (cable or module) to the main module 06 has four of its pins connected so that the main module connections 02 and 03 are connected (grounding TX5000 pin 17) and connections 04 and 05 are connected (connecting TX5000 pin18 to the micro-controller Transmit enable pin). Drawing 28 shows the ASK modulation where the connection (cable or module) to the main module 06 has four of its pins connected so that the main module connections 02 and 04 are connected (grounding TX5000 pin 18) and connections 03 and 05 are connected (connecting TX5000 pin17 to the micro-controller Transmit enable pin).

Drawing 13 shows one form of a Sensor module where 043 is a temperature, which could be a thermistor, 044 is a bridge form of sensor that could be a pressure or a wide variety of bridge type sensors. The sensors are supplied by power from a voltage regulator 045 and the sensed voltages are amplified by operational amplifiers 046 and fed to comparators 047, whose outputs are delivered to the Transponder microprocessor.

Drawing 14 shows diagrams of possible designs for transponder plug-in sensors; 048 shows a moisture testing probe that can be pushed into the soil and the tip of the probe has "pores" which allow a moisture sensor inside the probe to obtain a reading of relative moisture level. The transponder main module with it power module is simply plugged

into the probe connector which includes the standard OOK or ASK selection function, and other standard interconnections between sensor modules and the main module such as power and data lines, as well as the standard latching and sealing mechanisms. The floating pool sensor consists of a float 049 and a sensing unit 050 on the end of a "snorkel", where the sensing unit can contain a variety of elements to monitor pH, Chorine content, hardness and sensors that evaluate the water for possible dangerous contaminants. Although not shown, the multi-parameter sensing unit could be built into the water filtration system in which case the transponder would simply snap on to it in a similar manner to the moisture probe. An alternative form of the floating sensor would include a motion or vibration sensor (accelerometer) inside the submerged housing 051 that would provide information on momentary or sustained turbulence that might indicate something had fallen into the pool such as a small child or an elderly person. Item 052 is a typical security sensor that detect movement of people of objects in its vicinity but designed as a plug-in transponder module; 053 is a module that picks up polling signals; 054 monitors the status (open, open by how much or closed) or changing status (opening or closing) of doors, windows, containers, mail boxes, safes, vaults, etc; 055 represent safety monitors such as heat, fire, smoke, allergens and the presence of other harmful conditions designed as a plug-in transponder module; 056 a radioactive sensor , 057 a wind velocity sensor, 058 a rain gauge and 059 a blood pressure or pulse rate monitor. This latter application can be expanded to include anything monitoring life signs of chronically ill patients, particularly ambulatory patients who may not be under the constant care of another individual.

Drawing 15 shows a water Quality sensor that could be used in a pool monitoring application checking pH, chlorine concentration, hardness, etc. This Sensing Transponder could also include a vibration sensor that could be used to monitor water turbulence. In this the Transponder would be programmed to sample and analyze to identify sudden changes in turbulence, typical of a person or animal falling into the pool and struggling to get out. The Reader would be programmed to distinguish between normal pool usage and unintended entry into the pool. Furthermore the system is designed to receive information from multiple sources and analyze relationships. Children or elderly people using a pool or likely to be in the vicinity of a pool or pond could have a wrist or ankle transponder with a submersion sensor that would provide further input, and a polling receiver that would provide location input when passing through a pool gate or leaving the house. Depending on how the Water Monitoring Transponder was situated in the pool it could also include a physical or magnetic pool level indicator.

Drawings 16 and 17 show heart beat characteristics that we be monitored by a transponder attached to young babies, the elderly or chronically ill patients, along with other important life signs. Each EKG heartbeat has four positive-going voltage changes to peaks 060, 063, 069 and 068, two transition from below and cross zero volts 063 and 069; the phase of these two different wave sections can also be recorded. The fourth 068 is the start of a second heartbeat waveform P. Each heartbeat has three positive amplitudes 060,063 and 069. These three analog parameters would be monitored and analyzed. In addition timing criteria 061, 064, 065 and the timing of the peaks 060, 063 and 069 would also be monitored. Sampling would establish norms for absolute values

and the relative rate change of these characteristics, which when compared to absolute values, rate of change of values and comparison between characteristics as described in Drawing 08, anomalies requiring urgent attention can be identified.

In order to provide an effective interface between sensors of this sort and the Transponder microprocessor when measuring heart beat amplitudes such as R, the time from the moment the positive-going edge of R crosses zero (a little after Q) to the time the positive waveform T returns to zero, the time from the moment one positive-going edge of R crosses zero to the same place on the "next" waveform R. This EKG Transponder interface module may also include a clock, counter and timer, zero-crossing detectors, phase-angle detectors, comparators, amplitude measurements, memory and analog to digital coding. Further since "spike" R has the highest (steepest) phase angle and amplitude of the three positive wave sections in a heartbeat, this zero-crossing and steep phase-angle (representing part of a "high" frequency waveform vs the "low" frequency of the P and T waves) combination can be used as a start time. The negative-going wave sections from this time can be monitored and counted (Q->S continuing through T). From start time to when the second wave section T returns to zero is the second parameter. The amplitude of all positive waveforms can be sampled, stored and counted; if the second positive waveform also has the highest phase-angle and amplitude this is R and can be can be coded.

Drawing 18 shows such an interface with an oscillator, timing, A/D converters, voltage reference, comparators, logic, and some memory that can also provide voltage or current to sensors. Each such interface can handle or control either one analog input/detector at a time; or with multiplexing up to six such sensors.

Diagram 19 shows a means for detecting the removal of a wrist or ankle Transponder sued in instances described above. The Transponder Module 070 is connected to the Power Module 071 by a conductor 072 which passes through a clasp 073 returns to and passes under 070 around the other side of the wrist or ankle 074, to and passes under 071 back to other section of the clasp and then returns to the Power module 071. This design makes it impossible to remove the Transponder from the wrist with interrupting the power supply, either by unlatching the clasp or by cutting the conductive band 074. The Transponder has a power storage capacitor adequate to send a final transmission when power is disconnected. A final transmission of this nature has an added bit indicating the removal of power. This data bit will remain attached to transmissions until reset, to identify removal and perhaps reconnection to another person, or simply tossed aside to sabotage tracking and monitoring functions. The key to the continuity concept is demonstrated in the Clasp Detail 075. A 4-pin plug connects to a matching 4-pin socket enabling the power wiring to cross from one to the other and return, a process that occurs both for the connection between 070 and 073, as well between 071 and 073.

Diagram 20 shows a system installed in a home, monitoring it for a broad range of characteristics. A single Reader 076 placed in a central location and can receive and decode transmissions from any Transponder attached to any combination of sensors located on the property inside or outside the home. A fireplace in the living room, 077 is

monitored by Transponder 078, which has temperature and smoke sensors. It may also monitor the concentration of combustion products and toxicity vapors. Similar Transponders 079 and 081 are shown placed by fireplaces 080 and 082. In the event these fireplaces are gas operated, the transponders would also monitor for natural gas or propane leaks. The master bedroom Transponder 083 would monitor in a similar manner, but in this case perhaps sensing for smoldering caused by an improperly discarded cigarette or a poorly placed candle. Not shown could be a Transponder attached to a set of life signs sensors on an elderly or chronically ill patient. Transponder 084 would similarly monitor bathroom conditions but could also monitor for bath or toilet overflows, or electrical problems such as shorts or ground fault over loads. Transponder 085 is located in the dining room and may have an added sensor to monitor a food warmer or might monitor a normally locked china or silver cabinet for security purposes. The kitchen Transponders 086 would likely have a variety of sensors with a separate Transponder by each appliance. With a gas range it would include a sensor for gas leaks while an electrical range would have an overload detector. Other bedroom Transponders 087, 088 and 089 would be customized for the occupant, perhaps detecting for allergens, molds, bacteria or other airborne threats. Transponder 090 is located outside the house perhaps by a barbeque sensing for propane leaks in addition to the temperature and other sensors. Transponders 091 in the garage would sense for the same parameters as other sensors, but might also include a gasoline sensor, workbench electrical shorts and ground fault overloads. Vehicle mounted transponders could monitor tire pressures and battery condition, alerting the owner ahead of time to a potential flat tire or dead battery in the morning. Other transponders can be monitoring movement in each room, opening and closing doors and windows, be connected to thermostats and conventional security and safety devices like fire and smoke alarms, even monitoring such obscure criteria like termite or carpenter ant infestations. Also not shown in the drawing are other Transponders with sensors that can monitor, pool and garden gates, pools and ponds, mailboxes, even the moisture level in the soil for irrigation optimization. Solar heating systems, wind force, earth tremors can be monitored. City water can be monitored for purity and freedom from biological contaminants, and for sudden surges that might indicate a leak or burst pipe when compared with motion sensors that show no one is in the house. Similarly surges in electricity or gas usage could detect shorts or gas leaks, again the benefit of comparison with temperature rise, detection of combustion products or the detection of a high natural gas or propane concentration in the air.

Drawing 21 shows a high Yagi Antenna specification for achieving a 1500 read range

Drawing 22 shows a building application with a centrally located Reader 092 that locates transponders 093 and 094 that move, or may move, around the building, by locating fixed, coded, location pollers by each doorway 096, periodically along corridors 097 and at stairwells. As the moving Transponder passes within the very limited range of this directional poller, it receives and decodes the polling signal, adding that code to its own. The same Reader can receivers other Transponders monitor various building conditions such as doors open or closed, lights on and off or the status of other items 095.

Drawing 23 shows a building outfitted with pollers 102 that can be used to locate people, Laptop computers and other tagged assets as the move, are relocated or removed from rooms or the building, or even from one floor of the building to another. Pollable Transponders 101 will pickup, extract the Pollers' location identification code and add it to its own identification code which it then transmits to the Reader 103. The Poller might also include an additional bit to notify the control center of the transmission, status of each door (open or closed) or even whether the light is on in the room. The key here is the very short range and directionality of the pollers, that are simply another version of a Transponder, with a lower power transmitter and a directional antenna where required. The Transponders have been designed to be able to switch frequencies by simply a change of Transmitter hybrid component or by replacing it by a frequency programmable transmitter.

Drawing 24 shows a similar application to Drawing 23 except in this case the doorway modules are sensing Transponders, identifying open and closed doors, lights on or off, and other conditions, and transmitting the data to the Reader 105 periodically or immediately a change in status occurs. In this the Transponder 106, which can also be read by the Reader, would likely be a used just for identification purposes and perhaps to provide its own sensor information. It should be noted throughout these applications that the read range of the Readers can be programmed to limit the field being monitored. As will be seen later there is 16-bit remotely programmable attenuator in the Reader before the RF receiver circuit that is used to define the read range.

Drawing 25 shows a Responder version of the Transponder. In this application the components are only included in circuit 098 if the Poller is intended to operate only when it recognizes that a Transponder with a short pulse beacon is within range, it which case it will transmit its information, and where applicable its instructions, before shutting down. For Pollers without this circuit populated they are programmed to transmit intermittently. As a Poller the temperature monitoring circuit 099 is normally not populated but in some applications temperature, or temperature history, may be part of the information to be relayed by the Transponder back to the Reader, since the responder has only a very short range, or may be operating on a different frequency that the Reader. An example of this application might be a Responder that is monitoring an environment but there is no requirement to send this information directly to the Reader, or its not practical to do so, or the information is only important when a short pulse beacon Transponder is in the vicinity. The Responder transmitter hybrid 100 can in some circumstances have the same frequency as the Transponder, but in the majority of applications it would operate at a different frequency list in Drawing 10 or it may operate at 13.56MHz or a lower frequency.

Drawing 26 shows an example of a control center display such as might be used in the application show in Drawing 24. In this case each sensing transponder is designed to sense five conditions (this is an example of a one bit sensor response). A total of twenty Transponders are each monitoring five conditions such as doors, drawers, switches and other conditions open or closed, off or on, etc. The display identifies the Group Code, there may be more than one company using the building in which case the display might

be password protected to show only a particular Group Code. The next column identifies the unique Transponder code, followed by the status of each of the five conditions being monitored. A red entry indicates a change from the previous reported status and a bold line indicates that the Transponder is not reporting and shows the last received status. The display also provides other pertinent information. Instead of the template a building plan could be used similar to Drawing 24 and the door, drawer, lights, etc. could be shown actually open or closed, on or off, and a change highlighted in red and an un-read situation in another color. This could also we used where other Transponders are being monitored (such as location tags) in which case it could its location and movement around the building. Other conditions such as temperature, natural gas concentrations and the like can also be monitored if the appropriate transponder is installed.

Drawing 27 shows a system block diagram of a pollable Transponder 107, a Reader 108 and the polling transmitter 110. The poller can either instruct the Transponder to send its data immediately or provide other instructions. As in other system configurations the Reader 102 decodes and further analyzes the data before periodically sending the information on to a control center 103 PC or PDA. If an anomaly is confirmed it will send data immediately to whichever prescribed phone number or LAN address indicated for that particular event.

Drawing 28 shows a system block diagram of a Transponder 101 and Reader 102 with two-way communication. In this case the Reader can provide the Transponder with polling or other instructions instead of a separate polling transmitter. The benefit of this type of system is that it provides the Reader with the ability to interrogate the Transponder when it detects a problem but needs to modify the collection of further data. It also leads to the ability of introducing sensor modules 106 that also provide control functions when called for. As in other system configurations the Reader 102 decodes and further analyzes the data before periodically sending the information on to a control center 103 PC or PDA. If an anomaly is confirmed it will send data immediately to whichever prescribed phone number or LAN address indicated for that particular event. The transceiver feature also provides the ability for the control center that always has two-way communication with the Reader, to send instruction to the Transponder via the Reader that then serves as a two-way relay or repeater between the person receiving the data and the monitoring (and control) Transponder. The Transponder's RF section in this has the normal RF hybrid transmitter replaced by a Transceiver hybrid 105 and similarly for the Reader's RF receiver section 104.

Drawing 29 is a view of a sensing transponder. In this application the power module 105 and sensor module 106 each plug directly into the main module 107. The attachment cleats 108 can still be used for connection to the host.

Drawing 30 is an exploded view of the flat sensing transponder again showing power module housing 109, power module battery insert 110, housing for the main module 111, main module electronics 112, sensor electronics 113 and the sensor module housing 114. Other features shown are the sensor module multi-pin plug 115, matching main module

multi-pin socket 116 and socket 117 (for power module attachment) and power module plug 118.

Drawing 31 is view of the basic transponder consisting of the power module 119 plugged into the main module 120. In this case a snap cap 121 is used to seal the unused sensor module socket. There are several versions of this cap, one being a snap on cap used only for sealing purposes, and the others are using for setting certain transponder operating conditions. For example, the main module's hybrid transmitter can be operated in either an OOK modulation mode or ASK modulation mode. The appropriate cap is attached to achieve the selected modulation mode. It can be removed and replaced with the alternate cap version if the modulation method needs to be changed. All of the sensor modules and other special custom attachments have the same modulation setting option.

Drawing 32 is another exploded view of the basic transponder again showing power module housing 122, power module battery insert 123, housing for the main module 124, main module electronics 125 and the selected end cap 126. Other features shown are the end cap multi-pin plug 127, matching main module multi-pin socket 128 and socket 129 (for power module attachment) and power module plug 130.

Drawing 33 shows the use of a Transceiver Hybrid Circuit in place of the Transponders Transmitter and the Reader's Receiver. The drawing shows how the 16-bit programmable attenuator 200 can be inserted between the antenna and the Saw Filter (and before the inductors RFIO and ESD choke) to provide a field limiting function that prevents Transponder out of the desired range from being received, and how the 16-bit Signal Strength Comparator circuit 2001 can be used by tapping off the signal prior to the Peak Detector circuit.

Drawing 34 is an exploded view of the power module showing the housing 135, attachment cleats 136, and battery insert 137 and plug 138. The drawing also shows the sealing bullhead 139 that is present on all module inserts.

Drawing 35 shows close up view of the main module 140 containing the micro-controller, RF transmitter, polling circuit, temperature sensor, battery condition monitor, transmit inhibit switch and poll response LED. It shows the sensor interface sockets 141 and 142, cleats 143, and the sealing tongue 144.

Drawing 36 is an exploded close up view of the main module showing its case 145, attachment cleats 146, electronics PCB 147, socket 148 and 149, and the sealing bulkheads 150.

Drawing 37 shows close up view of the sensor module 151 showing the plug 152 that interfaces with the main module, cleats 153, and the sealing tongue 154.

Drawing 38 shows an exploded close up view of the sensor module showing the case 155, electronics PCB 156, plug 157 that interfaces with the main module and the sealing bulkhead 158, cleats 159, and the sealing tongue 165.

Drawing 39 shows the basic transponder (power module and main module) and a ribbon cable 166 plugged into the sensor interface socket 167. This cable serves a variety of purposes that include programming the micro-controller, testing the main module functionality including setting the modulation method to either OOK or ASK, or to interface sensors. In an actual installation where the transponder is connected to external sensors, the plug would be built into an end cap to provide a sealed assembly.

Drawing 40 shows the power module 168 connected to the main module 169, showing the cable and plug assembly 170 before insertion into the sensor connection socket 171.

Drawing 41 shows the main module 172 in a further test configuration where the power is also supplied through a plug in cable 173 allowing a complete in process test of the main at various voltage levels and to measure current drain in various modes and conditions of operation, and with various sensor loads. The main module alone, or with any form of sensor connection, can also be powered from an external source used this power cable connector but the plug would then be built into an end cap to provide a sealed assembly.

Drawing 42 shows the main module with the two unplugged cable connectors 174 and 175.

Drawing 43 is an exploded view of a sensing transponder.

Drawing 44 is a block diagram of the basic LIMIS Reader. The RF Section consists of an RF Receiver 177 with connectors for one or two (for diversity) antenna 176, an antenna-receiver impedance matching circuit and an OOK/ASK receiver (within 177). There are two identical RF sections per circuit as shown in this drawing. An optional 16-bit programmable attenuator stage(s) 181 may be included between the antenna(s) and the Receiver. The attenuator stage is controlled by the Microprocessor 186 directly, or on instructions to the Reader from the control center. This provides the ability to limit the receiving range of the Reader to the area of interest and reduces noise or collisions from other Transponders or Tags that are outside the area of interest.

The Analog Section has a gain circuit 178 that consists of a differential amplifier and a summing amplifier. The differential amplifier provides gain and offset adjustment while the summing amplifier adds the two (1 per receiver) signals together. The Analog Section also has a filter circuit 179 consisting of an active filter reduce signal noise. The Digital Section has a level detector 180 consisting of a 16 level voltage divider, 16 comparators and an upper and lower level voltage adjustment. The voltage divider provides 16 equally spaced voltage reference levels for the 16 comparators. Each comparator detects if the received signal is high or lower than its voltage reference. The upper and lower voltage references are adjusted using a potentiometer. This Level Detector serves to provide a calibrated 16 bit Signal Strength functions with the range sensitivity being controlled by the 32-bit processor 186. Where a 16-bit Attenuator Read-range adjustment feature is used, the output of the 16-bit Signal Strength function must be linked to the attenuator

setting. This could be used to provide a 256-bit Signal Strength function although this precision would rarely be used because of the many potential attenuating factors associated with radio signals. One application it can be used for, where the attenuating factors are specific to the nature of the environment and location, is to provide a very accurate analysis of these attenuating factors which could be determined prior to an installation and then programmed into the Reader or the central control computer, and used to refine the Signal Strength readings when using the system for locating purposes. The CPLD functions consist of a 16 level to 4-bit converter 182 that de-bounces the incoming bits and converts the data to a 4 bit binary code. A Digital Squelch function 182 is used to set a minimum signal value. Any signals below the digital squelch level are ignored. The Digital Filter 184 performs a weighted average on the signal. Each sample is weighted based on the age of the sample, and the older the sample the less weight a sample has in the average. This provides a smoother signal and reduces noise. A Slope Detector 185 looks for slope changes in the signal. There are currently 3 types of slopes detected (up, down & level). Any change in slope type is detected in the Event Rate Detector 187 and a pulse is generated. An 18-bit counter is used to keep a rolling count of the 4MHz clock 188 in a binary format. A Time Stamp Latch 190 latches whenever a pulse is latched from the 18-bit counter 189 whenever a pulse is received from the slope detector. All rollover events are also latched to aid in tracking event timing. All data captured in the time stamp latch 190 is also loaded into a 4K x 18 bit FIFO (First In First Out) 191 Memory device. The FIFO is used to store time stamps until the microprocessor is ready to read them. Event Rate Detector is used when time stamps occur at a rate that is faster than the known signal rate, it makes an automatic adjustment to the digital squelch circuit which effectively eliminates fast noise signals. The microprocessor reads data from the FIFO and analyzes the time stamps to decode data from the transmitter. The microprocessor also controls the potentiometers that adjust the upper and lower threshold levels. The microprocessor also sets the level in the digital squelch circuit, and acts as the interface to the system computer.

Drawings 45 to 54 show the PC-104 LITMIS Reader Board detailed circuit schematic and Drawing 55 to 62 show the detailed LITMIS PCMCIA Reader circuit schematic for the external antenna card with the range selection circuitry (drawing 56). Drawings 63 to 72 show the PCMCIA Reader board layout for the external antenna card, and Drawing 73 the layout with the internal Splatch component antenna. Drawing 74 shows the nature of the Splatch Planar Antenna this is used in the LITMIS PCMCIA Reader. Another advantage of using a PCMCIA Reader is that when used with a dual slot PCMCIA expansion Pak (such as iPAQ's), the second slot can be used with 802.11 Modem for communication with the control center.

Drawing 75shows a view of the assembled, fixed LITMIS PC-104 Reader 50 with mounting flange 51. Also shown is the dual PCMCIA slot 52, serial connector 53, power connector 54 and LAN connector 55. Also shown are ten coaxial connectors, one for a WLAN antenna 56, one for a GPS antenna 57, and eight connectors 58 providing coax cable connections to the maximum number of four, dual (orthogonal) antennae.

Drawing 76shows an exploded view of the fixed LITMIS PC-104 Reader showing the case 60, the cover 59 and mounting flanges 51, the dual PCMCIA slot 52, serial connector 53, power connector 54 and LAN connector 55. Also coax sockets 56, 57, and 58. The four PC-104 boards shown are PCMCIA two-slot Module 61 that can be used for GPS or 802.11 cards or even one of two LITMIS PCMCIA Readers (such as Aaeon PCM-3115B), CPU Module 62 (such as Aaeon PCM-4335 or 3336), Ethernet Module 63 (such as Aaeon PCM-3660) and the LITMIS Reader 64. Other PC-104 options include a Vehicle Power Supply Module for Wheel and Axel Monitoring Systems, fork lift, golf cart or similar applications, 48-channel DIO Module such as Aaeon PCM-33724), Isolated RS232/422/485 Module (such as Aaeon PCM-3610), or a Cell Phone/Internet Communications Board (including boards such as Ubicom's PhantomServer). All these are either alternates to the Ethernet Module or the stack can be expanded to include multiple options.

Drawing 77 shows a use of a pollable Transponder (that doesn't transmit unless polled) and a repetitively transmitting Poller, as a scoring method in a wide range of sporting events. A short-range Poller with a directional antenna is located on either end of the scoring line with the transmissions directed across the track so as to cover the full width of the scoring line and assure that a transponder crossing the line will receive the polling signal. The instant the transponder receives the polling signal it transmits its code to the Reader located nearby, thereby notifying the Reader that the Transponder has just crossed the scoring line, and time stamping that reception.

Diagram 78 shows a use of a pollable Transponder (that doesn't transmit unless polled) and a repetitively transmitting of a coded Poller as a scoring device in sporting events where there are a number of scoring lines periodically spaced over a wide area. A short-range coded Poller with a directional antenna is located on either end of the scoring line with the transmissions directed across the track so as to cover the full width of the scoring line and assure that a transponder crossing the line will receive the polling signal. The instant the Transponder receives the coded polling signal it transmits its code along with the Poller's code to the Reader located anywhere within a 1500 foot radius, thereby notifying the Reader that the Transponder has just crossed a specific scoring line, and time stamping that reception.

A further version of this scoring method involves replacing the coded Poller with a coded Responder, a polling device that only transmits its code when it receives a prompt from a Transponder in range. In this method the Transponder, in addition to the functions described previously, also sends out a very narrow low power beacon pulse every tenth of a second to every second, depending on race speeds (walkers, runners, skiers, sleds, horses, vehicles), except when it is sending its polled data to the Reader. The Responder acts as a pollable Poller. In other words a Poller that only transmits a polling signal when it receives a beacon prompt.

Drawing 79 shows a sensor application that provides the ability to provide remote surveillance of stored radioactive items and to detect radiation in monitored

environments. The application has the ability to handle nonproliferation monitoring, spent fuel safeguards and long term monitoring of stored radioactive wastes by using the features of LITMIS that sample, average, establish parameter normals and then continuously compare readings every few seconds against absolute and rate of change limits. Data transmissions to the Reader can be hourly or daily except when anomalies are detected in which case transmissions can be repetitive or continuous depending on the seriousness of the condition.

Drawing 80 shows a LITMIS PCMCIA Reader card 202 plugged into an iPAQ PDA Expansion Pak. In this case the PCMCIA Reader has an internal stub or Spatch antenna. Although not shown where a dual PCMCIA slot expansion Pak is used, an 802.11 modem card can also be inserted to provide radio communication to the central monitoring computer. In this configuration the LIMIS PCMCIA Reader must be the Splatch version and the card must have a reverse connection into the slot compared to the 802.11 Modem. All Splatch versions of the PCMCIA Reader are configured that way, thus avoiding communication problems because of the close proximity of the two PCMCIA cards. This orientation problem does not occur when PCMCIA Readers have an external antenna. Another configuration option is to use both slots for LITMIS Reader cards with external antennae that are designed to be extended into to perpendicular directions to provide a diversity feature if the application calls for it.

Drawing 81 shows the LITMIS system components concepts described in this document.

Drawings 82, 83 and 84 show an alternative encoding method that can also be used with the LITMIS hardware where it use is intended for much larger numbers of Transponders for a large number of potential customers.

Two additional sets of commercial documents (each five pages) are also attached that describe a ground moisture sensor that can be used with LITMIS product, and an Event Detector Interface that can be used in place of the Sensor Module. In this case the sensor Module would have a mechanical design similar to the main module allowing for either an end cap when sensors are included in the Event Detector Module or a Ribbon Cable Plug-in when Event Sensors are remote to the LITMIS Transponder itself.

APPLICATIONS (<u>To be edited to relate to hospital monitoring applications</u>

The breadth of systems applications that can be covered by the modular, re-programmable, multi-sensor options of the transponder and the ability to deliver the received information to remote locations, particularly involving cell phone and internet connection is the innovative aspect of the invention. In many cases the Transponder itself, or the Reader or central computer could allow monitoring of selected sensed parameter for a period of time while it "learns" what the typical variation of that parameter is and establishes normal maximum and minimum values for it. After that period of time the system would only notify the owner (or designated overseer) when a value goes outside that acceptable range.

For example: Security Related Applications

A multi-application installation is remote security and safety monitoring of containers, storage areas, warehouses, water supplies, utility plants, industrial and commercial facilities, and transportation centers. Key features include:

Adaptable to any combination of sensors, transducers or detectors with analog or digital outputs. Small, multi-application, field re-programmable wireless data monitoring of people and environments. Continuous sampling to identify anomalous absolute and rate of change conditions. Ability to notify programmed locations of emergencies and provide real-time data. Provision for adding multiple sensors or sites for expanded monitoring or enhanced situation analysis. Provides multiple level decisions from the Transponder to the Control Center personnel. Anomalous parametric data can be selectively presented as warnings, alerts or alarms. All Internationally approved wireless bands, very low power, narrow pulse, periodic transmission

Examples of monitored parameters:

1. Anomalous Radiation (indicating the presence of Radioactive Materials.
2. Explosives Emissions or detection of selected Chemical or Biological Agents.
3. Electricity Usage (abnormality indicating lost of power, a short or unusual usage)
4. Water Quality (identifying the presence of poisons or contaminants)
5. Natural Gas Usage (abnormality indicating a lost of service or a leak)
6. Fluid Level in Fuel Oil or Gas storage tanks (indicates a leak or refueling need)
7. Temperature (abnormality indicating a lost of heat or air conditioning, or a fire
8. Humidity (abnormality indicating a medically required humidification system malfunction)
9. Allergens (medical risk from bacteria or other air born particulates or contaminants)
10. Light Level (abnormality indicating lights left on or a possible intrusion)
11. Noise Level (abnormality indicating dog barking, something breaking or phone ringing)
12. Circuit Breakers (indicating tripped breaker, perhaps an alarm failure)
13. Weight or Load (abnormality indicating overload or over stressed condition)
14. Identifying Movement (sensing of invaded premises or unauthorized presence)
15. Identifying Open Doors or Windows or other Security Breeches (monitoring locks/switches)
16. Locating or tracking Items, People, Vehicles and Objects

The system has the ability to analyze simultaneous input from multiple sensors thus providing the means, as programmed by user, to better understand the nature of anomalous data and the rate at which it is changing in real time, and to be able to do this at a remote location.

Similar sets of applications achievable with a single installation include commercial offices and workplaces, warehouses and factories, manufacturing plants and power stations, maintenance depots, theme parks, underground mines, military deployments,

marshalling yards, airports, docks, shipping containers, vehicles, planes, ships and in fact in any situation where a combination of Location, Identification, Tracking, Monitoring, Interrogation and/or Sensing functions are required and particularly where real time notification of persons remote from the site is necessary. The major feature of this innovation is the ability to accomplish all of the above functions with a single modularized, post-programmable design that can deliver the sensed or interrogated information from anywhere to anywhere instantly. The firmware in transponders can be re-programmed in the field and Reader software can be re-programmed through a wide choice of wired or wireless options. If it can be sensed, it can be remotely monitored without wired connections.

Another application: Residential Monitoring

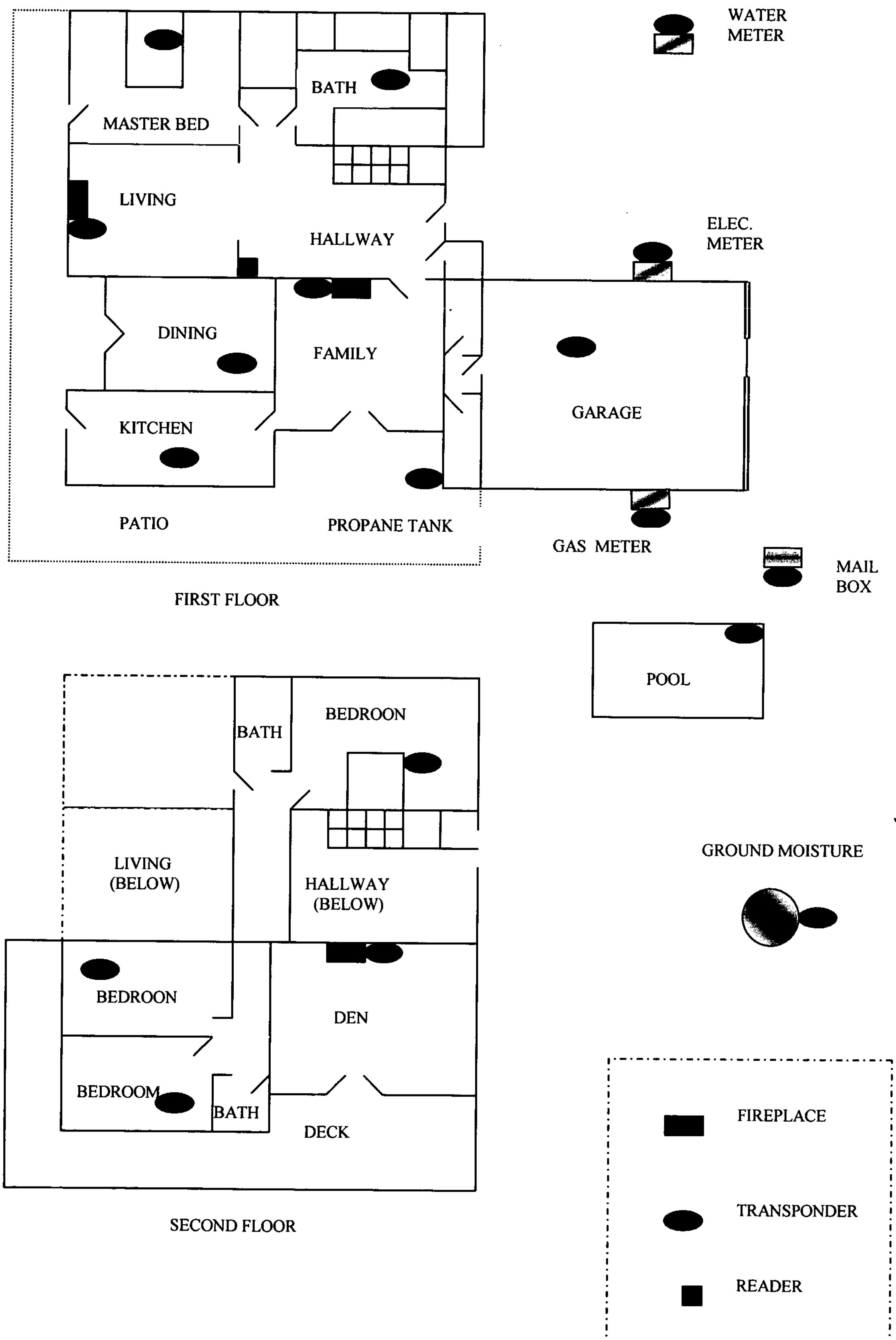
1. Monitoring Electricity Usage (abnormality indicating lost of power or a short)
2. Monitoring Natural Gas Usage (abnormality indicating a lost of service or a leak)
3. Monitoring Water Usage (abnormality indicating a lost of supply or a leak)
4. Monitoring Fluid Level in Fuel Oil or Gas storage tanks (indicates order needed)
5. Monitoring Temperature (abnormality indicating a lost of heat or air conditioning, or a fire or appliance/oven/hot plate left on)
6. Monitoring Humidity (abnormality indicating a medically required humidification system malfunction)
7. Monitoring Allergens (abnormality indicating a potential medical risk from excess pollen, dust, bacteria or other air born particulates or contaminants)
8. Monitoring Light Level (abnormality indicating lights left on or the sun is up)
9. Monitoring Noise Level (abnormality indicating dog barking, something breaking or phone ringing)
10. Monitoring Pool or Pond Water Level (abnormality indicating overflow or water needed)
11. Monitoring Pool Water Condition (abnormality indicating pH, Chlorine, hardness and contaminant problem)
12. Monitoring Pool or Pond Water Agitation (abnormality indicating something or someone fell or jumped into the pool, or there is a strong wind or an earthquake)
13. Monitoring Fish Pond Water Quality (abnormality indicating lack of Oxygen, presence of poisons or other contaminants)
14. Monitoring Soil Moisture Level (abnormality indicating failure of irrigation to expensive newly planted trees or broken line causing flooding)
15. Monitoring Lawn Moisture Level (abnormality indicating failure of irrigation or jammed sprinkler head)
16. Monitoring Rainfall/Snowfall and rate of precipitation (abnormality indicating a need for taking some action – perhaps turning off the sprinkler)
17. Monitoring Wind Speed/Gusts (abnormality indicating a need for taking some action – take down awnings and implement damage control)
18. Monitoring Density of Wooden Rafters and Studs (abnormality indicating possible infestation of Termites or Wood eating beetles)

19. Monitoring Freezer/Refrigerator Temperature (abnormality indicating failure and risk to food and perishables)
20. Monitoring Vehicle Tire Pressure from inside the house (abnormality indicating overnight air leak)
21. Monitoring Vehicle Fluid Levels from inside the house (abnormality indicating a need for coolant, fuel, oil or brake fluid before driving off)
22. Monitoring Solar Heating/Power Generation (abnormality indicating a system failure requiring attention)
23. Monitoring Elderly or Chronically Ill Patients (lack of movement or a fall indicating a need for checking on them, even monitoring blood sugar, pulse, etc.)
24. Monitoring Mail Box Opening (indicating delivery of mail, illegal removal of mail and mail box destruction)
25. Monitoring Circuit Breakers (indicating tripped breaker, perhaps an alarm failure)
26. Monitoring Weight or Load (abnormality indicating overload or over stressed condition)
27. Identifying Movement (sensing of invaded premises or unauthorized presence)
28. Identifying Open Doors or Windows (sensing a young child getting out, teens arriving home at night, a door or window left (or blown) open, garage door open)
29. Identifying Security Breeches (sensing a safe or security vault being opened, or a secure area being entered, or an valuable item being removed)
30. Locating Items, People or Pets (integrated into a single monitoring system)

Similar sets of applications achievable with a single installation include commercial offices and workplaces, warehouses and factories, manufacturing plants and power stations, maintenance depots, theme parks, underground mines, military deployments, marshalling yards, airports, docks, vehicles, planes, ships and in fact in any situation where a combination of Location, Identification, Tracking, Monitoring, Interrogation and Sensing functions are required and particularly where real time notification of persons remote from the site is required. The major feature of this innovation is the ability to accomplish all of the above functions with a single modularized, post-programmable design that can deliver that information from anywhere to anywhere instantly. The firmware in transponders can be re-programmed in the field and software in the Readers can be re-programmed through a wide choice of wired or wireless options.

HOME MONITOR LAYOUT

Sensors include Temp, Smoke, Motion, Doors/Windows open, leaks (Gas or Water), Allergens, Electrical Shorts, Baby or Elderly Health Monitoring, etc.



REMOTE MONITOR AND CONTROLLER
Starter Kit

Home Version

Assume scope of monitoring and control is required to cover:

- Outside Lights front and rear (2)
- Garage light and overhead door (2)
- Downstairs and upstairs hallway lights (2)
- Living room lights (2)
- Dining room light (1)
- Family room lights and TV (3)
- Kitchen light, stove and refrigerator (3)
- Bathroom lights (2)
- Bedroom lights (3)
- Laundry room light, washer and drier (3)
- Miscellaneous (pool, security system, etc.) (2)

A total of twenty-five unique transponders are required.

Requirements

Transponders capable of monitoring the status of the host (i.e. on or off), receiving and decoding a personal polling signal, transmitting the status information in response to receiving a unique poll, receiving and decoding a personal status-change signal, and changing the status of the host (i.e. on to off or off to on).

A handheld Transceiver capable of addressing, interrogating and receiving the status of each transponder's host, and be capable of sending a signal to change that status.

Assumptions

- All system components to be battery powered. The transponder batteries are required to last five years and the Transceiver battery to be easily replaceable (equivalent to a TV remote control).
- RF communication is to be by unlicensed short-range wireless data per FCC Part 15-329.

RadioData Corporation

Home Safety/Security Applications for the Universal Wireless Monitoring System

November 1, 2002

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RadioData Corporation

Company

RadioData Corporation was founded in April 2001, and incorporated as an Arizona "C" corporation in December 2001. The Company's objective is to become a worldwide leader in the development, commercialization, manufacture and marketing of Radio Frequency LITMIS (Location, Identification, Tracking, Monitoring, Interrogation and Sensing) hardware products and systems. The RFID industry, particularly as related to real time data collection, is one of the fastest-growing sectors of the economy, and RadioData intends to capitalize on the experience and success of the founders in this and related technologies. RadioData is also working with strategic partners in preparing real-time data collection and control software, and wireless communication protocols that provide Value Added Retailers (VARs) and System Integrators an interface to these RFID/LITMIS related products.

President and CEO John J. Coulthard has over 40 years experience in developing, manufacturing and marketing of application-specific electronic products and has held the position of Vice-President of Product Engineering for a leading RFID systems where he managed the development and deployment of a very successful real-time RFID asset tracking system that was the largest operational system of that type in the world. Prior to that he co-founded, co-owned and operated several electronics companies based on the technology utilized in RadioData's products. Chief Financial Officer Quinn Bastian has over 25 years of corporate level financial experience Including serving as CFO of a leading RFID company where he was responsible for all aspects of accounting, financing, forecasting, cash management, investor relations and crisis management, Chief Technical Officer Dr. Paul McArthur has over 20 years of experience in a wide range of management and consulting positions with numerous electronic companies particularly companies in the medical electronics field. Vice President of Marketing Paul Smith has more than forty years of marketing management experience in the electronics field. He held various sales and marketing positions in General Electric Company before being promoted to the Director of Sales Training for the nationwide Electronic Component Sales Operation where he implemented the first nationwide sales training program for all component sales personnel within General Electric.

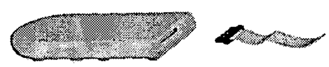
Product

RadioData has developed the concept of a modularized, multi-application, post-programmable set of small, inexpensive, RF products that provide location, identification, tracking, monitoring interrogation and/or sensing functions based on a standard re-configurable Transponder and universal fixed and mobile Readers that can receive and decode all versions of transponders and relay this information to a central computer, send it via the Internet to an E-mail address or in an emergency situation send it to a cell phone or PDA.

This versatile system consists of five basic system components:

- Transponders with a Power Module, a Main Module with micro-controller and RF transmitter, and a wide choice of Sensing and Polling Receiver Modules, or an interface to external sensors.
- Readers with the ability to receive any sensor combinations, to handle up to eight arrayed antennae and having options of any wired and wireless real time communication to anywhere on the world.
- Portable Handheld Readers used with Pocket PCs and other PDAs for localized search and interrogation functions that can also have an 802.11 communications link.
- Mobile Readers for use in vehicle Wheel and Axle Monitoring Systems, or used with RadioData Portable Locators or with a wide variety of mobile equipment.
- Polling Transmitters with a choice of communications method and encoding options.

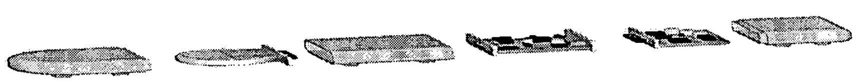
Remote Sensor Transponder



Status

The Company has completed the strategic design of its initial products and is in the process of completing their commercialization and qualification prior to marketing release.

Exploded View of Transponder with Sensor Module



RadioData offers these products in seven frequency options (303.825MHz, 315MHz, 418MHz, 433MHz, 865MHZ, 913.5MHz and 916MHz); companies have the opportunity of using a single hardware source (backed by leaders in contract manufacturing) to meet any type of application worldwide. RadioData is the only company with the skill, expertise and market understanding to provide hardware that truly meets the application specific nature so necessary for its clients to dominate their respective markets.

Home Monitoring Application

One example of a multi-application installation is home monitoring that can include a wide variety of functions such as:

Monitoring Electricity Usage (abnormality indicating lost of power or a short)
Monitoring Natural Gas Usage (abnormality indicating a lost of service or a leak)

Monitoring Water Usage (abnormality indicating a lost of supply or a leak)
Monitoring Fluid Level in Fuel Oil or Gas storage tanks (indicates order needed)
Monitoring Temperature (abnormality indicating a lost of heat or air conditioning, or a fire or appliance/oven/hot plate left on)
Monitoring Humidity (abnormality indicating a medically required humidification system malfunction)
Monitoring Allergens (abnormality indicating a potential medical risk from excess pollen, dust, bacteria or other air born particulates or contaminants)
Monitoring Light Level (abnormality indicating lights left on or the sun is up)
Monitoring Noise Level (abnormality indicating dog barking, something breaking or phone ringing)
Monitoring Pool or Pond Water Level (abnormality indicating overflow or water needed)
Monitoring Pool Water Condition (abnormality indicating pH, Chlorine, hardness and contaminant problem)
Monitoring Pool or Pond Water Agitation (abnormality indicating something or someone fell or jumped into the pool, or there is a strong wind or an earthquake)
Monitoring Fish Pond Water Quality (abnormality indicating lack of Oxygen, presence of poisons or other contaminants)
Monitoring Soil Moisture Level (abnormality indicating failure of irrigation to expensive newly planted trees or broken line causing flooding)
Monitoring Lawn Moisture Level (abnormality indicating failure of irrigation or jammed sprinkler head)
Monitoring Rainfall/Snowfall and rate of precipitation (abnormality indicating a need for taking some action – perhaps turning off the sprinkler)
Monitoring Wind Speed/Gusts (abnormality indicating a need for taking some action – take down awnings and implement damage control)
Monitoring Density of Wooden Rafters and Studs (abnormality indicating possible infestation of Termites or Wood eating beetles)
Monitoring Freezer/Refrigerator Temperature (abnormality indicating failure and risk to food and perishables)
Monitoring Vehicle Tire Pressure from inside the house (abnormality indicating overnight air leak)
Monitoring Vehicle Fluid Levels from inside the house (abnormality indicating a need for coolant, fuel, oil or brake fluid before driving off)
Monitoring Solar Heating/Power Generation (abnormality indicating a system failure requiring attention)
Monitoring Elderly or Chronically Ill Patients (lack of movement or a fall indicating a need for checking on them, even monitoring blood sugar, heart rate, blood pressure, etc.)
Monitoring New-born Babies (a variety of life signs that might fore warn of crib death, arrhythmia, fever or other critical health risks in infants)
Monitoring Mail Box Opening (indicating delivery of mail, illegal removal of mail and mail box destruction)
Monitoring Circuit Breakers (indicating tripped breaker, perhaps an alarm failure)
Monitoring Weight or Load (abnormality indicating overload or over stressed condition)
Identifying Movement (sensing of invaded premises or unauthorized presence)

MEDICAL AND HEATHCARE RELATED
TRACKING, MONITORING AND INTERPRETIVE SENSING

Applications

Here is a list of possible applications followed by an excerpt from a document aimed at introducing RadioData's LITMIS technology entitled "Universal Monitoring System – Medical". I sent a Home Monitoring version of this earlier. None of these documents have yet been issued.

The primary objective of LITMIS is to emulate human intelligence in certain limited functions appropriate to specific situations and do so using existing technology and components wherever possible. For example a human has senses that provide sight, hearing, feeling, tasting and smelling and technology can duplicate these often with a great deal more accuracy and analytical skills. But often it is necessary for a human to do more than decide if something is too hot, too loud, too heavy, too fast, too dark, too dry or smells too strongly. Technology can already do that much. Often it is combination of sensed parameters, their rate of change, their relationships, the nature of the location and the specifics of the situation, all of which are evaluated by a human to first determine what is normal and then to compare real time changes to determine whether a situation is becoming abnormal and whether action should be taken and if so when and what. Technology also exists to provide help in this respect (telemetry) but typically it is expensive, provides a vast amount of information and often leaves a human being with the task of trying to decipher whether anomalies exist and to do so fast enough to take corrective action.

LITMIS technology was developed to distribute this process of interpretive sensing right to the sensing site using Transponders that can receive several sensor based inputs providing analog, digital and condition information, as well as location and other information from other nearby Transponders, analyze this input, determine what is normal and what is abnormal, and take appropriate action to forward the information when it's appropriate to a Reader that covers an assigned area. The Reader stores past information and is only sent information that is important to the updating of that information. The

Reader can then take this data, with similar data from all other Transponders in its read range, and analyze this collective information before determining that certain new information must be sent to the control center. Likewise the control center receives this kind of anomaly information from all of the Readers in the system and can further analyze the circumstances before presenting the critical information to the human monitoring the facility. Of course the database contains all the pertinent information that has been collected and which can be used for future analysis as needed.

The objective is to use only as much power as is necessary (particularly where battery power is being used), to only transit radio signals when it is necessary to provide new and vital information, and to provide a person monitoring the environment with the pertinent information directly.

To accomplish this the product has to be cost-effective (in terms of acquisition, installation and operation), versatile, reliable, backwards and forwards compatible, and easily expanded to provide additional capabilities as required.

This is the essence of LITMIS technology.

Application List

1. Locate and track people, equipment and items accurately in Multi-story buildings.
   Note: this does not rely on RF signal strength or GPS technology as do other systems that are not accurate or reliable in multi-story buildings and are also significantly more expensive. The accuracy of location can be enhanced by simply increasing the number of low cost, location identifying Pollers.)

2. Relate people, equipment and items to each other, to their location and to the condition of their local environment.
   Examples of this are monitoring temperature, humidity, light, sound, the existence of allergens or vapors, air borne biological or chemical contaminants, and other conditions that can be sensed and linked to a individual's sensitivities who may be in or approaching that environment or location. Another example is a baby leaving a monitored nursery area with its mother or a member of the

hospital staff, or without the presence of an authorized person. The latter would be an abnormal situation and the hospital staff should be alerted, but not if the situation is normal. Suppose while outside the nursery the baby becomes separated from the authorized person or even if still in their company enters a non-appropriate area of the hospital or is approaching an area with a harmful environment then an alert would be issued.

3. Timing and condition relationships such as whether a piece of equipment was decontaminated, refurbished or replenished when necessary between patent use, is the correct equipment, material or fluid for that patient, whether the pressure or IV flow rate is appropriate for a particular patient, while moving around the hospital or in a certain location.

   Examples of equipment that needs to be located, its condition identified before and during use and possibly even its operation monitored are: Accur Check Machines, Infusion Pumps - Pat Con Analgesic, Infusion Pumps (Pole and IV), Isolation Carts, K-Pad Modules, Patient Moving Devices, Portable Bladder Scanners, Portable EKGs, Portable Pulse Oximeters, Portable Ultrasounds, Portable X-rays, Specialty Beds, Vitals Carts, Wheel Chairs by type, Patient Charts, etc.

"Universal Monitoring System – Medical"
Medical Related Applications

One example of a multi-application installation is in-home or care-center remote monitoring of high-risk babies or pregnant women, the elderly, chronically ill patients, the mentally incapacitated or those with serious allergies. Key features include:

- Comfortable, convenient and unencumbered, wireless data monitoring of people and environments
- Continuous sampling to identify anomalous absolute and rate of change conditions
- Ability to notify programmed locations of emergencies and provide real-time data
- Provision for adding multiple sensors or sites for expanded monitoring or enhanced situation analysis
- It can provide multiple level decisions from the Transponder to the Health Care Professional
- Anomalous environmental or personal data can be presented as warnings, alerts or alarms
- All FDA approved wireless bands, very low power, narrow pulse, periodic transmission

Examples of monitored parameters:

- Heart beat characteristics, Pulse rate, Blood Pressure and other vital signs
- Breathing of New-born Babies (forewarn of crib death, fever or other problem)
- Room Temperature (abnormality indicating a lost of heat or air conditioning)
- Room Humidity (abnormality indicating a medically required humidification system malfunction)
- Allergens (pollen, dust, bacteria or other air born particulates or contaminants)
- Lack of Movement of Elderly or Chronically Ill Patients (indicating a fall or incapacitation)
- Light or Noise Level (abnormality indicating lights left on or something breaking)

The system has the ability to analyze simultaneous input from multiple sensors thus providing the means, as programmed by the health care professional, to better understand the nature of anomalous data and the rate at which it is changing in real time from a remote location.

Similar sets of applications achievable with a single installation include commercial offices and workplaces, warehouses and factories, manufacturing plants and power stations, maintenance depots, theme parks, underground mines, military deployments, marshalling yards, airports, docks, shipping containers, vehicles, planes, ships and in fact in any situation where a combination of Location, Identification, Tracking, Monitoring and Interpretive Sensing functions are required and particularly where real time notification of persons remote from the site is necessary. The major feature of this innovation is the ability to accomplish all of the above functions with a single modularized, post-programmable design that can deliver the sensed or interrogated information from anywhere to anywhere instantly. The firmware in transponders can be re-programmed in the field and Reader software can be re-programmed through a wide choice of wired or wireless options. If it can be sensed, it can be remotely monitored without wired connections.

TRANSPONDER SENSOR DESIGNED FOR HEART MONITORING

Each EKG heartbeat has four positive-going voltage changes, all circled in green, two transition from below and cross zero volts; circled in purple, (the phase of these two different wave sections may someday be important).
The fourth (rightmost) is the start of a second heartbeat waveform P. Each heartbeat has three positive amplitudes, see blue P, R and T.

At present the need is to read and digitally encode three analog parameters of an EKG waveform into a format that may be transmitted for short distances to a receiver that will decode the information.

1. The amplitude of R.
2. The time from the moment the positive-going edge of R crosses zero (a little after Q) to the time the positive waveform T returns to zero.
3. The time from the moment one positive-going edge of R crosses zero to the same place on the "next" waveform R.

The EKG Transponder (PCB) may also include a clock, counter and timer, zero-crossing detectors, phase-angle detectors, comparators, amplitude measurements, memory and analog to digital coding.

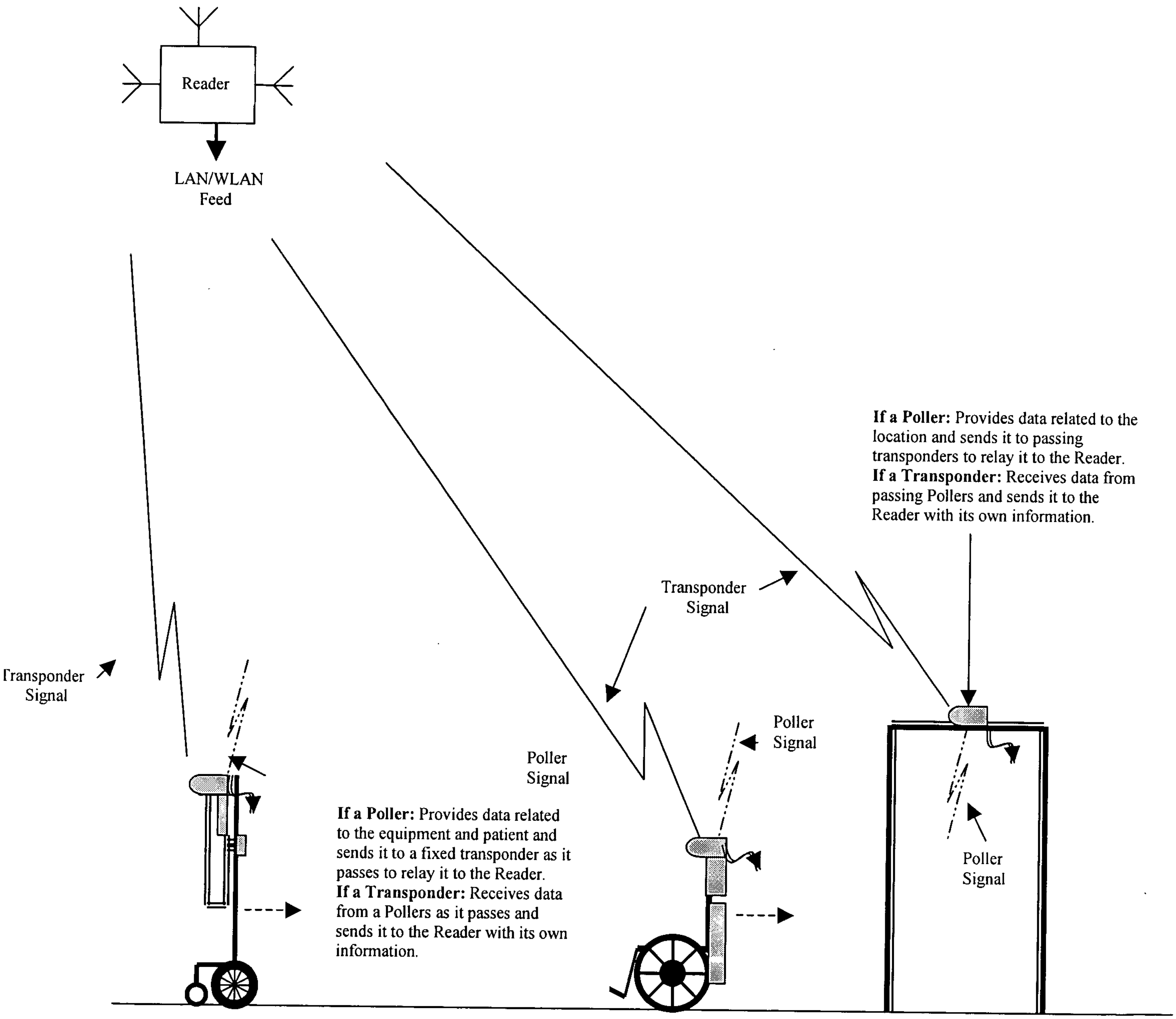
These ideas are embedded in the electronics design.

Since "spike" R has the highest (steepest) phase angle and amplitude of the three positive wave sections in a heartbeat, I suggest this zero-crossing and steep phase-angle (representing part of a "high" frequency waveform vs the "low" frequency of the P and T waves) combination be used as a start time. See 3 above.

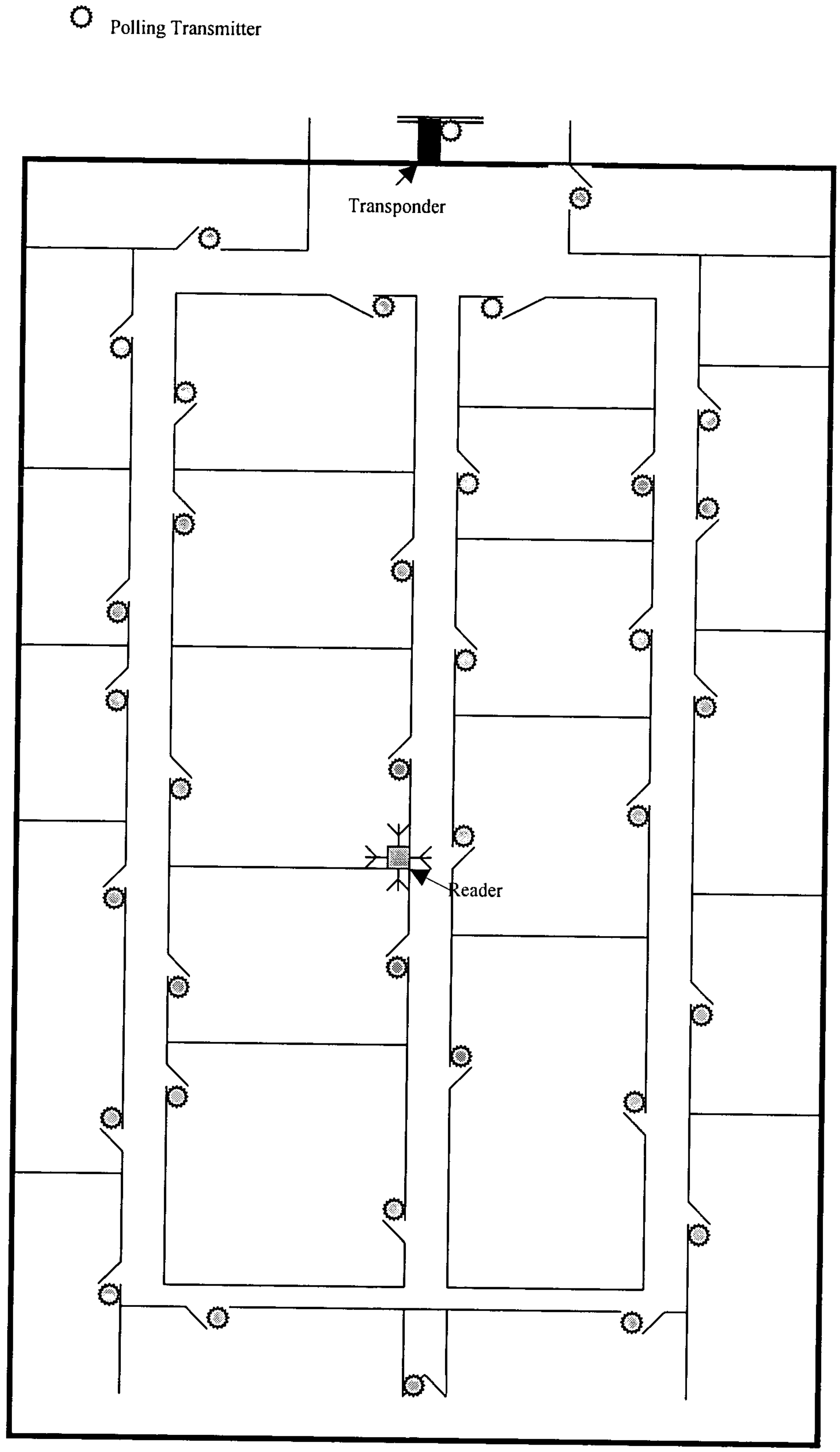
The negative-going wave sections from this time can be monitored and counted (Q->S continuing through T). From start time to when the second wave section T returns to zero is the second parameter.

The amplitude of all positive waveforms can be sampled, stored and counted; if the second positive waveform also has the highest phase-angle and amplitude this is R and can be can be coded. See 1 above.

The single chip electronics has an oscillator, timing, A/D converters, voltage reference, comparators, logic, and some memory. It can also provide voltage or current to sensors. Each chip can handle or control ONE analog input/detector at a time; without multiplexing of some sort.

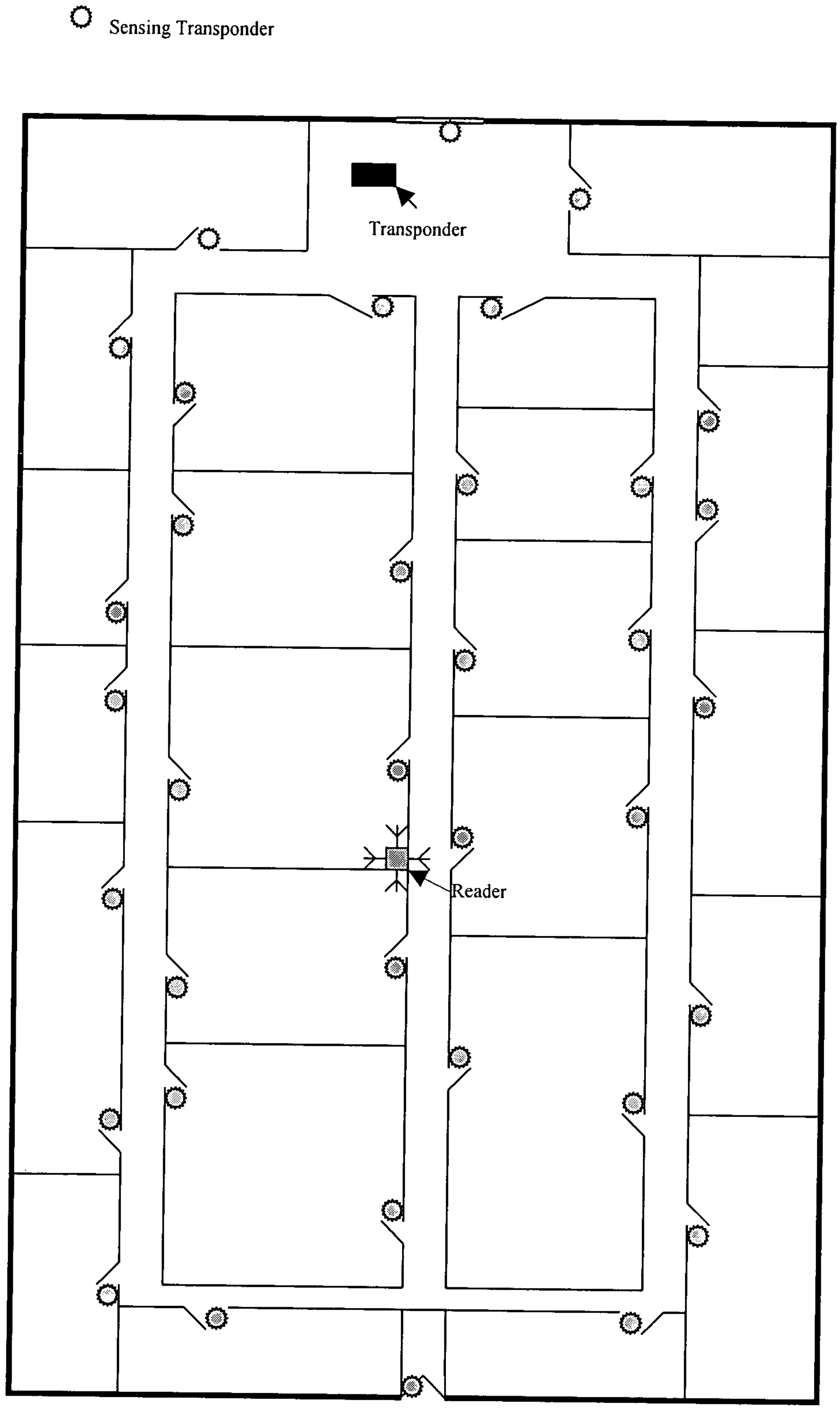


Hospital Configuration Options
DIAGRAM ___



Location by Short-range Coded Polling of Transponders

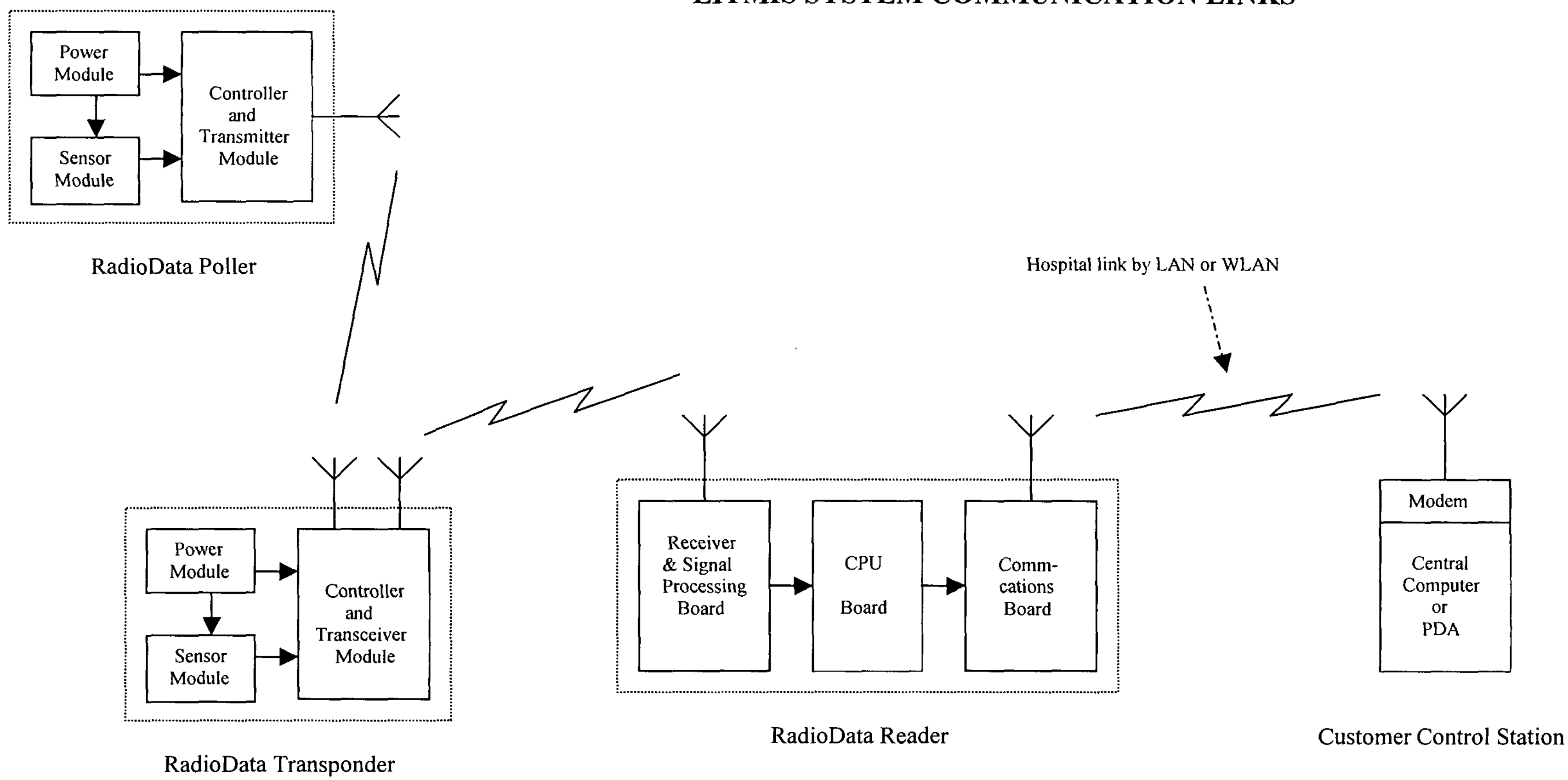
Diagram 3



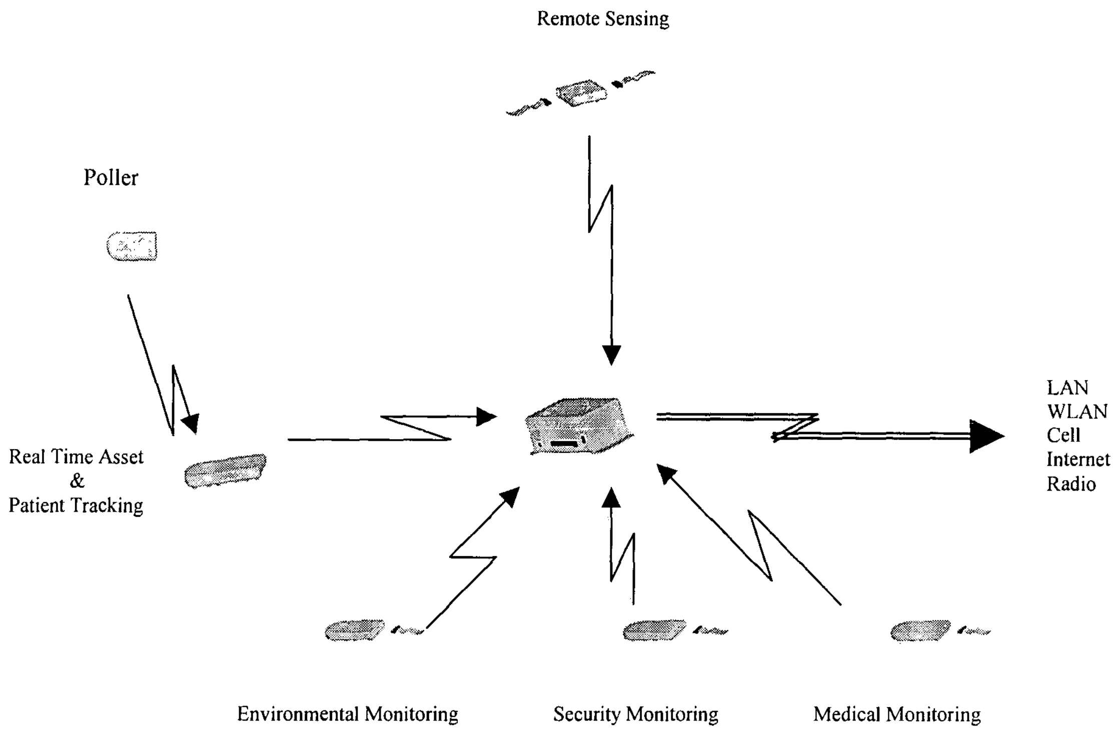
Status of Doors, Lights , etc.

Diagram 3

LITMIS SYSTEM COMMUNICATION LINKS



LITMIS Used for Hospital Equipment Location, Status, Tracking and other functions



Microsoft Excel

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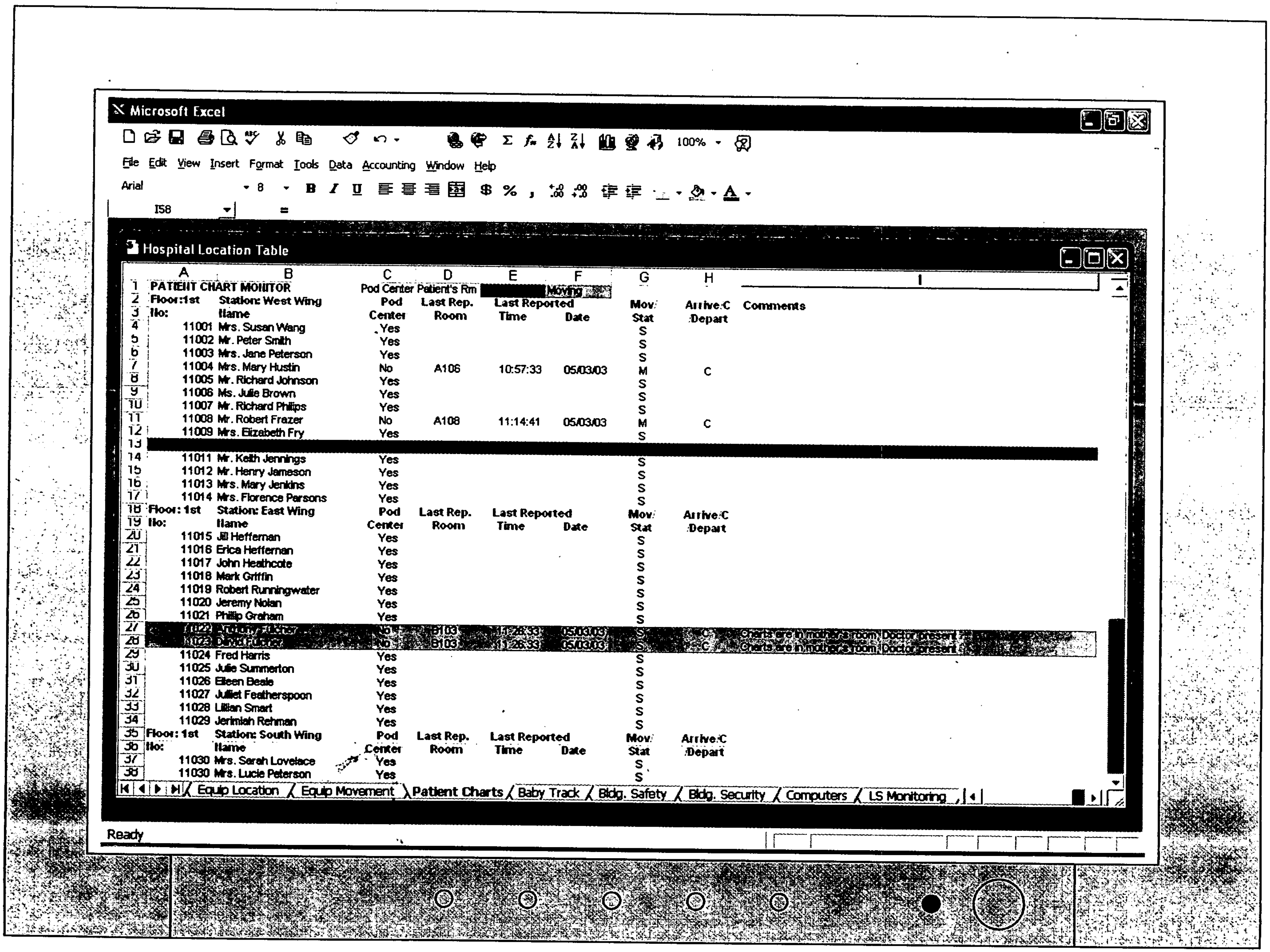
D3 = Not monitoring

Hospital Location Table 1

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	No.	Item Name or Description	Serial	Last Location		Prior Location		Last Reported		In Use	Operنl.	Moving	Notes
2			Number	Room	Floor	Room	Floor	Time	Date	Y/N	Y/N	Y/N	
3													
4	10002	Accur Check Machine	SN0002	C111	5	C116	3	19:18	06/25/03	Y	Y	N	
5	10003	Accur Check Machine	SN0003	A106	6	A102	1	0:31	06/19/03	N	Y	N	
6	10004	Accur Check Machine	SN0004	C103	5	C111	5	22:25	06/20/03	N	Y	Y	
7	10005	Infusion Pump P/C Anal.	SN0101	B115	4	B108	1	13:02	05/31/03	N	Y	N	
8	10006	Infusion Pump P/C Anal.	SN0102	C107	3	C102	6	1:33	05/18/03	N	Y	N	
9	10007	Infusion Pump P/C Anal.	SN0103	A100	3	C105	3	10:26	06/06/03	N	Y	Y	
10	10008	Infusion Pump Pole/IV Pump	SN0104	B110	6	B111	2	14:36	06/25/03	Y	Y	N	
11	10009	Infusion Pump Pole/IV Pump	SN0105	C105	3	B102	4	12:31	06/25/03	Y	Y	N	
12													
13	10011	Isolation Cart	SN0202	C115	2	C113	6	7:49	06/25/03	Y	Y	N	
14													
15													
16	10014	K-Pad Module	SN0301	A110	1	A109	2	4:41	05/10/03	N	Y	N	
17	10015	K-Pad Module	SN0302	B114	2	B114	2	11:59	05/29/03	N	Y	N	
18	10016	K-Pad Module	SN0303	A114	5	B101	1	5:44	06/08/03	N	Y	Y	
19	10017	Patient Moving Device	SN0401	B113	1	C114	4	0:31	06/25/03	Y	Y	N	
20	10018	Patient Moving Device	SN0402	B105	4	C112	3	15:07	06/25/03	Y	Y	N	
21	10019	Patient Moving Device	SN0403	C110	1	C104	5	17:12	06/25/03	Y	Y	N	
22	10020	Portable Bladder Scanner	SN0501	B109	1	B106	5	0:00	05/06/03	N	Y	N	
23													
24	10022	Portable EKG	SN0601	B108	1	B107	6	1:02	06/25/03	Y	Y	N	
25													
26	10024	Portable EKG	SN0603	B112	6	C115	2	8:20	03/12/03	N	Y	N	
27	10025	Portable Pulse Oximetery	SN0701	C117	2	B105	4	23:59	06/25/03	Y	Y	N	
28	10026	Portable Pulse Oximetery	SN0702	C108	2	A110	1	4:10	05/21/03	N	Y	Y	
29	10027	Portable Ultrasound	SN0801	B104	4	A103	2	16:41	04/19/03	N	Y	N	
30	10028	Portable Ultrasound	SN0802	A115	1	C103	5	18:46	06/25/03	Y	Y	N	
31	10029	Portable X-ray	SN0901	C106	5	B113	1	15:39	06/25/03	Y	Y	N	
32	10030	Portable X-ray	SN0902	A104	3	C117	2	6:15	06/25/03	Y	Y	N	
33	10031	Specialty Beds	SN1001	A112	2	B109	1	20:52	04/14/03	N	Y	N	
34	10032	Specialty Beds	SN1002	A107	6	A115	1	21:54	05/22/03	N	Y	N	

Equip Types / Equip Location / Equip Movement / Patient Charts / Baby Track / Bldg. Safety / Bldg. Security / Computers

Ready



	A	B	C	D	E	F	G	H	I
1	PATIENT CHART MONITOR		Pod Center	Patient's Rm		Moving			
2	Floor:1st	Station: West Wing	Pod	Last Rep.	Last Reported		Mov/	Arrive:C	Comments
3	No:	Name	Center	Room	Time	Date	Stat	:Depart	
4	11001	Mrs. Susan Wang	Yes				S		
5	11002	Mr. Peter Smith	Yes				S		
6	11003	Mrs. Jane Peterson	Yes				S		
7	11004	Mrs. Mary Hustin	No	A106	10:57:33	05/03/03	M	C	
8	11005	Mr. Richard Johnson	Yes				S		
9	11006	Ms. Julie Brown	Yes				S		
10	11007	Mr. Richard Philips	Yes				S		
11	11008	Mr. Robert Frazer	No	A108	11:14:41	05/03/03	M	C	
12	11009	Mrs. Elizabeth Fry	Yes				S		
13									
14	11011	Mr. Keith Jennings	Yes				S		
15	11012	Mr. Henry Jameson	Yes				S		
16	11013	Mrs. Mary Jenkins	Yes				S		
17	11014	Mrs. Florence Parsons	Yes				S		
18	Floor: 1st	Station: East Wing	Pod	Last Rep.	Last Reported		Mov/	Arrive:C	
19	No:	Name	Center	Room	Time	Date	Stat	:Depart	
20	11015	Jill Heffernan	Yes				S		
21	11016	Erica Heffernan	Yes				S		
22	11017	John Heathcote	Yes				S		
23	11018	Mark Griffin	Yes				S		
24	11019	Robert Runningwater	Yes				S		
25	11020	Jeremy Nolan	Yes				S		
26	11021	Phillip Graham	Yes				S		
27	11022	Anthony Fulcher	No	B103	11:26:33	05/03/03	S	C	Charts are in mother's room. Doctor present
28	11023	David Fulcher	No	B103	11:26:33	05/03/03	S	C	Charts are in mother's room. Doctor present
29	11024	Fred Harris	Yes				S		
30	11025	Julie Summerton	Yes				S		
31	11026	Eileen Beale	Yes				S		
32	11027	Julliet Featherspoon	Yes				S		
33	11028	Lillian Smart	Yes				S		
34	11029	Jerimiah Rehman	Yes				S		
35	Floor: 1st	Station: South Wing	Pod	Last Rep.	Last Reported		Mov/	Arrive:C	
36	No:	Name	Center	Room	Time	Date	Stat	:Depart	
37	11030	Mrs. Sarah Lovelace	Yes				S		
38	11030	Mrs. Lucie Peterson	Yes				S		

Microsoft Excel

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M56 =

Hospital Location Table

	A	B	C	D	E	F	G	H	I	J	K	L	M
17	EQUIPMENT MOVEMENT LOG				10005	Infusion Pump P/C Anal.				SN0101			Note: Equipment in use or on standby
18	Last Location		Last Reported		Mov/	Arrive/C	In Use	Opernl.	Not in Use	Moving	In Use	Inoperable	Comments
19	Room	Floor	Time	Date	Stat	Depart	Y/N	Y/N	hr:min:sec	hr:min:sec	hr:min:sec	hr:min:sec	
20	C101	4	6:37:22	05/02/03	S	A	N	Y	28:19:56				
21	C107	4	10:58:13	05/03/03	M	A	N	Y		0:00:56			
22	C107	4	10:58:14	05/03/03	S	C	N	Y		0:01:02			
23	C107	4	10:58:20	05/03/03	S	C	Y	Y	00:00:06				
24	C107	4	11:45:30	05/03/03	S	C	N	Y			0:47:10		Used satisfactory and released
25	C107	4	13:35:41	05/03/03	M	C	N	Y	01:50:11				
26	C107	4	13:35:43	05/03/03	M	D	N	Y		0:00:02			
27	C108	4	13:35:46	05/03/03	M	A	N	Y		0:00:05			
28	C108	4	13:35:48	05/03/03	M	D	N	Y		0:00:07			
29	E004	4	13:35:52	05/04/03	M	A	N	Y		0:00:11			
30	E004	4	13:35:53	05/04/03	S	C	N	Y		0:00:12			
31	E004	4	13:36:26	05/04/03	M	C	N	Y	00:00:33				
32	E004	4	13:36:28	05/04/03	S	C	N	Y		0:00:02			
33	E004	1*	13:36:48	05/05/03	M	C	N	Y	00:00:20				
34	E004	1*	13:36:57	05/05/03	M	D	N	Y		0:00:09			
35	A108	1	13:37:06	06/19/03	M	A	N	Y		0:00:18			
36	A108	1	13:37:08	06/19/03	M	D	N	Y		0:00:20			
37	A107	1	13:37:13	06/19/03	M	A	N	Y		0:00:25			
38	A107	1	13:37:15	06/19/03	M	D	N	Y		0:00:27			
39	A106	1	13:41:06	06/19/03	M	A	N	Y		0:04:18			
40	A106	1	13:41:08	06/19/03	M	D	N	Y		0:04:20			
41	A105	1	13:41:10	06/19/03	M	A	N	Y		0:04:22			
42	A104	1	13:41:11	06/19/03	M	A	N	Y		0:04:23			
43	A105	1	13:41:12	06/19/03	M	D	N	Y		0:04:24			
44	A104	1	13:41:13	06/19/03	M	D	N	Y		0:04:25			
45	A103	1	13:41:15	06/19/03	M	A	N	Y		0:04:27			
46	A103	1	13:41:17	06/19/03	M	D	N	Y		0:04:29			
47	A103	1	13:41:27	06/06/03	S	C	N	Y		0:04:39			
48	A103	1	13:42:55	06/06/03	S	C	Y	Y	00:01:28				
49	A103	1	14:18:25	06/06/03	S	C	N	Y			0:35:30		Used satisfactory and released
50	A103	1	14:54:49	06/06/03	S	C	S	Y	00:36:24				Standby for possible need again
51	A103	1	15:24:31	06/06/03	S	C	N	Y			0:29:42		Equipment was needed a second time
52			Period	Total					30:48:53	0:05:55	1:52:22		
53			Period	Percent					94.0%	0.3%	5.7%		
54													

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Hospital Location Table

BABY REMOVAL TRACKING 11027 Julliet Featherspoon

	Commentary	Last Location Room	Last Location Floor	Last Reported Time	Last Reported Date	Mov Stat	Arrive/Depart	Notes	Action Recommended
1	Intended Location - Nursery	C101	4	6:37:22	05/02/03	S	A	Not authorized for removal	
2	Moving in Room	C101	4	10:57:18	05/03/03	M	-	First warning	
3	Removed from Room - Alarm	C101	4	10:57:23	05/03/03	M	D	Alarm issued	Alert Security - Code D
4	Moving west down C Corridor	C102	4	10:57:28	05/03/03	M	A	Alarm Condition - Tracking	
5	Moving west down C Corridor	C102	4	10:57:33	05/03/03	M	D	Alarm Condition - Tracking	
6	Moving west down C Corridor	C103	4	10:57:38	05/03/03	M	A	Alarm Condition - Tracking	
7	Moving west down C Corridor	C103	4	10:57:43	05/03/03	M	D	Alarm Condition - Tracking	
8	Moving west down C Corridor	C104	4	10:57:48	05/03/03	M	A	Alarm Condition - Tracking	
9	Moving west down C Corridor	C105	4	10:57:53	05/03/03	M	A	Alarm Condition - Tracking	
10	Moving west down C Corridor	C104	4	10:57:58	05/03/03	M	D	Alarm Condition - Tracking	
11	Moving west down C Corridor	C105	4	10:58:03	05/03/03	M	D	Alarm Condition - Tracking	
12	Moving west down C Corridor	C106	4	10:58:08	05/03/03	M	A	Alarm Condition - Tracking	
13	Moving west down C Corridor	C106	4	10:58:08	05/03/03	M	D	Alarm Condition - Tracking	
14	Moving west down C Corridor	C107	4	10:58:13	05/03/03	M	A	Alarm Condition - Tracking	
15	Moving west down C Corridor	C107	4	10:58:14	05/03/03	S	C	Alarm Condition - Tracking	
16	Moving west down C Corridor	C107	4	11:00:01	05/03/03	M	C	Alarm Condition - Tracking	
17	Moving west down C Corridor	C107	4	11:00:13	05/03/03	M	D	Alarm Condition - Tracking	
18	Moving west down C Corridor	C108	4	11:00:16	05/03/03	M	A	Alarm Condition - Tracking	
19	Moving west down C Corridor	C108	4	11:00:21	05/03/03	M	D	Alarm Condition - Tracking	
20	At C Corridor Elevator	E004	4	11:00:24	05/04/03	M	A	Potential floor change	
21	At C Corridor Elevator	E004	4	11:00:29	05/04/03	S	C	Potential floor change	
22	At C Corridor Elevator	E004	4	11:02:06	05/04/03	M	C	Potential floor change	
23	At C Corridor Elevator	E004	4	11:02:08	05/04/03	S	C	Potential floor change	
24	On E004 Elevator	E004	4	11:02:09	05/04/03	M	D	Potential floor change	
25	On E004 Elevator	E005	1*	23:02:13	05/05/03	M	A	Potential floor change	
26	At A Corridor Elevator	E004	1*	11:04:14	05/05/03	M	C	Potential floor change	
27	At A Corridor Elevator	E004	1*	11:04:17	05/05/03	M	D	Potential floor change	
28	Moving east down A Corridor	A108	1	11:04:19	06/19/03	M	A	Alarm Condition - Tracking	
29	Moving east down A Corridor	A108	1	11:04:21	06/19/03	M	D	Alarm Condition - Tracking	
30	Moving east down A Corridor	A107	1	11:04:23	06/19/03	M	A	Alarm Condition - Tracking	
31	Moving east down A Corridor	A107	1	11:04:25	06/19/03	M	D	Alarm Condition - Tracking	
32	Moving east down A Corridor	A106	1	11:04:28	06/19/03	M	A	Alarm Condition - Tracking	
33	Moving east down A Corridor	A106	1	11:04:30	06/19/03	M	D	Alarm Condition - Tracking	
34	Moving east down A Corridor	A105	1	11:04:33	06/19/03	M	A	Alarm Condition - Tracking	
35									

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Hospital Location Table

	A	B	C	D	E	F	G	H	I
1	PATIENT LOCATION			Patient's Rm	Elsewhere	Moving	Surgery		
2	Floor:1st	Station: West Wing	Patient	Last Rep.	Last Reported		Mov/	Arrive:C	Comments
3	No:	Name	NEED	Room	Time	Date	Stat	Depart	
4	11001	Mrs. Susan Wang	No	C100	10:32:45	05/03/03	S	C	In the cafeteriaw/ oxygen assist at 50cc/m
5	11002	Mr. Peter Smith	Yes	A110	10:57:13	05/03/03	S	C	Calling for nurse
6	11003	Mrs. Jane Peterson	No	C100	10:31:25	05/03/03	M	C	In the cafeteria
7	11004	Mrs. Mary Hustin	No	A106	10:57:33	05/03/03	M	C	With visitors
8	11005	Mr. Richard Johnson	No	B145	11:25:49	05/03/03	M	D	Moving down corridor B West with IV drip at 125cc/m
9	11006	Ms. Julie Brown	No	A113	11:25:14	05/03/03	M	D	Moving down corridor B East in wheel chair, oxygen at 55%
10	11007	Mr. Richard Philips	No	D101	10:56:12	05/03/03	S	C	IN SURGERY
11	11008	Mr. Robert Frazer	No	A108	11:14:41	05/03/03	M	C	Moving about room
12	11009	Mrs. Elizabeth Fry	No	A110	11:25:14	05/03/03	S	A	Indisposed
13									
14	11011	Mr. Keith Jennings	No	A119	11:25:14	05/03/03	S	C	In the TV room
15	11012	Mr. Henry Jameson	No	A121	10:56:12	05/03/03	S	C	With visitors
16	11013	Mrs. Mary Jenkins	No	A142	11:14:41	05/03/03	S	C	With IV drip at 150cc/m
17	11014	Mrs. Florence Parsons	No	A120	10:31:25	05/02/03	-	D	Released
18	Floor: 1st	Station: East Wing	Patient	Last Rep.	Last Reported		Mov/	Arrive:C	
19	No:	Name	NEED	Room	Time	Date	Stat	Depart	
20	11015	Jill Heffernan	No	B103A	11:25:49	05/03/03	S	C	
21		Erica Fulcher	No	C103	11:25:14	05/03/03	M	A	Moving down corridor B West with mother
22	11017	John Heathcote	No	B103E	10:32:45	05/03/03	S	C	With mother
23	11018	Mark Griffin	No	B103H	10:31:25	05/03/03	S	C	
24	11019	Robert Runningwater	No	B103K	11:25:49	05/03/03	S	C	
25	11020	Jeremy Nolan	No	B103I	11:25:14	05/03/03	S	C	
26	11021	Philip Graham	No	B103F	11:25:49	05/03/03	S	C	With mother
27	11022	Anthony Fulcher	No	B104A	11:26:33	05/03/03	S	C	With mother
28	11023	David Fulcher	No	B104K	11:26:33	05/03/03	S	C	With mother
29	11024	Fred Harris	No	B104G	10:32:45	05/03/03	S	C	With mother
30	11025	Julie Summerton	No	B104B	11:25:14	05/03/03	S	C	
31	11026	Eileen Beale	No	B104A	10:31:25	05/03/03	S	C	
32	11027	Juliet Featherspoon	No	B104D	10:32:45	05/03/03	S	C	With mother
33	11028	Lillian Smart	No	B104H	11:25:49	05/03/03	S	C	With mother
34	11029	Jerimiah Rehman	No	B104C	11:25:14	05/03/03	S	C	
35	Floor: 1st	Station: South Wing	Patient	Last Rep.	Last Reported		Mov/	Arrive:C	
36	No:	Name	NEED	Room	Time	Date	Stat	Depart	
37	11030	Mrs. Sarah Lovelace	No	C114	11:26:33	05/03/03	S	C	
38	11030	Mrs. Lucie Peterson	No	C115	10:32:45	05/03/03	S	C	

Equip Types / Equip Location / Equip Movement / Patient Charts / Baby Track / Bldg. Safety / Bldg. Security / Computers

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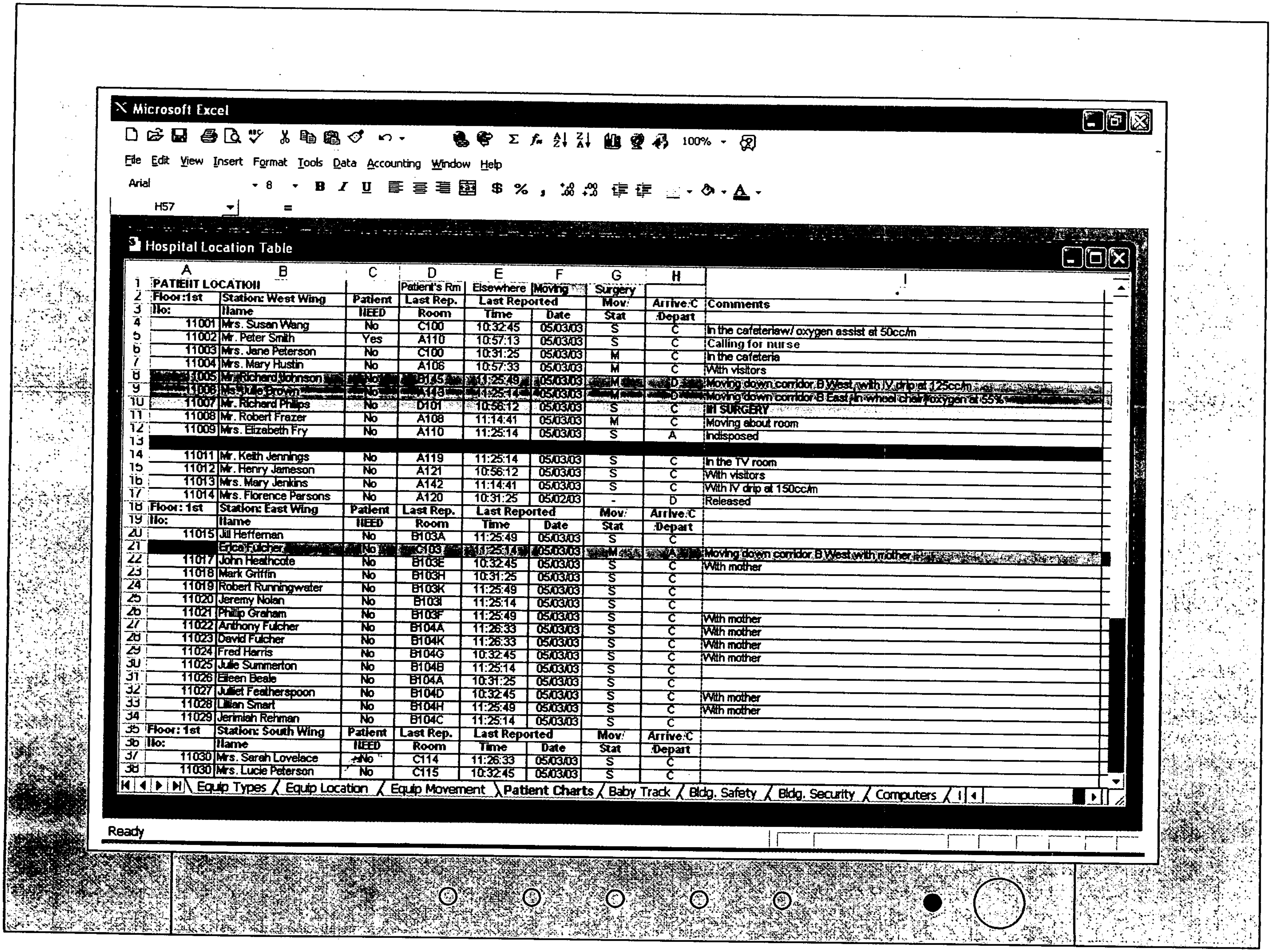
RadioData Corporation	LITMIS SENSOR STATUS REPORT	Model DTO 10021
Change from Prior Report	**Transponder Not Reporting (last status)**	Sensing of Door Status

TRANSPONDER CODE	Group	Individual	SENSOR A	SENSOR B	SENSOR C	SENSOR D	SENSOR E
01	ADFJ-1	132658	Open	Closed	Closed	Open	Open
02	ADFJ-1	132659	Open	Open	Open	Open	Open
03	ADFJ-1	132660	Closed	Closed	Open	Open	**Open**
04	ADFJ-1	132661	Closed	Open	Closed	Open	Open
05	ADFJ-1	132662	Open	Open	**Closed**	Closed	Open
06	ADFJ-1	132663	Open	Open	**Open**	Open	Closed
07	ADFJ-1	132664	**Open**	Closed	Open	Open	Open
08	ADFJ-1	132665	Open	Closed	Closed	Open	Open
09	ADFJ-1	132666	Closed	Closed	Open	Closed	Open
10	ADFJ-1	132667	Open	Open	Open	Closed	Closed
11	ADFJ-2	132745	Open	Open	Open	Closed	**Closed**
12	ADFJ-2	132746	Open	**Closed**	Closed	Open	Closed
13	ADFJ-2	132747	Closed	Closed	Closed	Closed	**Open**
14	ADFJ-2	132748	Closed	Open	Closed	Open	Open
15	ADFJ-2	132749	Closed	Open	Open	Open	Open
16	ADFJ-2	132750	Closed	Open	Open	**Open**	Closed
17	ADFJ-2	132751	Closed	**Open**	Closed	Closed	Open
18	ADFJ-2	132752	Closed	Closed	Closed	Closed	Open
19	**ADFJ-2**	**132753**	**Open**	**Closed**	**Open**	**Closed**	**Open**
20	ADFJ-2	132754	Closed	Closed	Open	Open	Closed

Report AC-10235	Date June 14, 2003	Time 12:45 am	Satust Beta Test 2A



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Hospital Location Table

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5	11002	Mr. Peter Smith	Yes	A110	10:57:13	05/03/03	S	C	Calling for nurse
6	11003	Mrs. Jane Peterson	No	C100	10:31:25	05/03/03	M	C	In the cafeteria
7	11004	Mrs. Mary Hustin	No	A106	10:57:33	05/03/03	M	C	With visitors
8	11005	Mr. Richard Johnson	No	B145	11:25:49	05/03/03	M	D	Moving down corridor B West with IV drip at 125cc/m
9	11006	Ms. Julie Brown	No	A143	11:25:14	05/03/03	M	D	Moving down corridor B East in wheel chair/oxygen at 55%
10	11007	Mr. Richard Philips	No	D101	10:56:12	05/03/03	S	C	IN SURGERY
11	11008	Mr. Robert Frazer	No	A108	11:14:41	05/03/03	M	C	Moving about room
12	11009	Mrs. Elizabeth Fry	No	A110	11:25:14	05/03/03	S	A	Indisposed
13									
14	11011	Mr. Keith Jennings	No	A119	11:25:14	05/03/03	S	C	In the TV room
15	11012	Mr. Henry Jameson	No	A121	10:56:12	05/03/03	S	C	With visitors
16	11013	Mrs. Mary Jenkins	No	A142	11:14:41	05/03/03	S	C	With IV drip at 150cc/m
17	11014	Mrs. Florence Parsons	No	A120	10:31:25	05/02/03	-	D	Released
18	Floor: 1st	Station: East Wing	Patient	Last Rep.	Last Reported		Mov/	Arrive:C	
19	No:	Name	NEED	Room	Time	Date	Stat	:Depart	
20	11015	Jill Heffernan	No	B103A	11:25:49	05/03/03	S	C	
21		Erica Fulcher	No	C103	11:25:14	05/03/03	M	A	Moving down corridor B West with mother
22	11017	John Heathcote	No	B103E	10:32:45	05/03/03	S	C	With mother
23	11018	Mark Griffin	No	B103H	10:31:25	05/03/03	S	C	
24	11019	Robert Runningwater	No	B103K	11:25:49	05/03/03	S	C	
25	11020	Jeremy Nolan	No	B103I	11:25:14	05/03/03	S	C	
26	11021	Phillip Graham	No	B103F	11:25:49	05/03/03	S	C	With mother
27	11022	Anthony Fulcher	No	B104A	11:26:33	05/03/03	S	C	With mother
28	11023	David Fulcher	No	B104K	11:26:33	05/03/03	S	C	With mother
29	11024	Fred Harris	No	B104G	10:32:45	05/03/03	S	C	With mother
30	11025	Julie Summerton	No	B104B	11:25:14	05/03/03	S	C	
31	11026	Eileen Beale	No	B104A	10:31:25	05/03/03	S	C	
32	11027	Juliet Featherspoon	No	B104D	10:32:45	05/03/03	S	C	With mother
33	11028	Lillian Smart	No	B104H	11:25:49	05/03/03	S	C	With mother
34	11029	Jerimiah Rehman	No	B104C	11:25:14	05/03/03	S	C	
35	Floor: 1st	Station: South Wing	Patient	Last Rep.	Last Reported		Mov/	Arrive:C	
36	No:	Name	NEED	Room	Time	Date	Stat	:Depart	
37	11030	Mrs. Sarah Lovelace	No	C114	11:26:33	05/03/03	S	C	
38	11030	Mrs. Lucie Peterson	No	C115	10:32:45	05/03/03	S	C	